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AN AIR TO GROUND AND GROUND TO AIR COMBINED ARMS COMBAT SIMULAT--ETC(U)

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AN AIR TO GROUND AND GROUND TO AIR
COMBINED ARMS COMBAT SIMULATION
(STAR-AIR)

by

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and

William Daniel Meiers

September 1979

Thesis Co-Advisors: J.K. Hartman
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A simulated battle is presented with a detailed explanation of the output to enable the reader to appreciate the potential applications of the model. This model represents an expansion

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An Air to Ground and Ground to Air
Combined Arms Combat Simulation
(STAR-AIR)

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This thesis presents a stochastic simulation model of ground to air and air to ground combat within the combined arms ground combat environment. The tactics represented, model capabilities and input requirements are explained in detail.

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I. INTRODUCTION

The mobility of high performance aircraft and helicopters has added a new dimension to modern warfare. The tremendous destructive potential of air to ground munitions requires that the modern Army, if it is to survive, must be capable of defense from air attack. Likewise, the ground force commander must commit his own air assets to change the ratio of combat power in his favor, capitalizing on the high mobility afforded by aircraft to meet the threat at the critical time and place. No modern army can expect to win unless its maneuver forces make maximum use of airpower while insuring that its ground forces operate under a cohesive and extensive umbrella of air defense.

The simulation of tactical alternative responses (STAR) combined arms model developed by Wallace and Hagewood [Ref. 15] is a battalion level model of combined arms combat representing two-sided ground to ground weapon systems. This thesis is an enhancement of STAR incorporating both BLUE and RED aviation and air defense weapon systems, within the brigade level combined arms environment.

The capabilities of the model are discussed in Chapter II in order to present the reader an overview of the model with little regard to the mechanics of the computer coding.

Chapter III details the data input requirements for executing the model. This chapter is included to give the

reader an appreciation of the level of detail and the flexibility in choosing tactics as well as the control afforded the user in specifying the values of many key parameters.

Chapter IV contains a description of the forces and tactics used in the sample battle, and Chapter V presents the sample battle output and discusses it in considerable detail.

Chapter VII discusses limitations and future model enhancements envisioned by the authors.

The intent of this thesis is not a detailed documentation of how the model represents air to ground and ground to air combat but rather an explanation of capabilities and the level of detail the model is capable of playing. The reader interested in the actual computer code and the detailed documentation of the computer code is referred to ref. 11 which contains the documentation of STAR-AIR as well as all other modules and components of the Brigade STAR model.

II. MODEL CAPABILITIES

A. INTRODUCTION

The purpose of this chapter is to outline the tactics modelled in STAR-AIR. The structure of the model is flexible to allow for the expansion of routines to incorporate additional tactics. The BLUE air weapon systems explicitly modelled are the advanced attack helicopter (AAH), the advanced scout helicopter (ASH) and the A-10 fixed-wing aircraft. The model allows for deployment of the AAH or A-10 in segregated flights or as members of a joint air attack team (JAAT) with or without the ASH. RED air weapon systems explicitly modelled are the Hip and the Hind attack helicopters. The BLUE air defense weapons include the Man Portable Air Defense Systems (MANPADS), mobile missile systems such as the Roland , Chapparal or Patriot, and the mobile gun systems such as the Vulcan or the Division Air Defense (DIVAD) Gun. RED air defense weapons include the SA-7 MANPADS, the SA-6, SA-8, and SA-9 mobile missile systems and the mobile gun systems such as the ZSU-23/4. MANPADS weapons may be represented as individual systems or as a type of ammunition carried on board systems such as the Soviet BMP or US Infantry Fighting Vehicle.

The weapon systems and ammunition types represented in the sample simulation are presented in Table I. Missiles may be represented as command guided to the target, command

TABLE I

WEAPON SYSTEM AND AMMUNITION CODES

SYS.TYPE CODE	WPN.TYPE CODE	WEAPON NAME	Ammunition Code and Ammunition Attribute Name			
			1 AMMO1	2 AMMO2	3 AMMO3	4 AMMO4
5	1	AAH	HELLFIRE ATGM	---	20mm Cannon	---
5	2	ASH	---	---	7.62mm MG	---
5	4	HIND	ATGM	57mm Rkts	20mm Gun	---
5	5	HIP	ATGM	57mm Rkts	20mm Gun	---
3	1	SA-7	AD Missile	---	---	---
3	2	STINGER	AD Missile	---	---	---
6	3	ROLAND	AD Missile	---	---	---
6	5	DIVAD	---	---	35mm Gun	---
6	6	SA-9	AD Missile	---	---	---
6	9	ZSU -23	---	---	23mm Gun	---

guided to a fixed distance from the target and then terminally guided by on-board guidance or missiles may be represented as fire and forget type weapons.

B. DETECTION

STAR-AIR allows detections to occur in numerous ways depending upon the equipment characteristics being simulated for each weapon system. Aircraft may detect other aircraft only visually but may detect ground elements visually or by using thermal imaging equipment. Air Defense forces may detect aircraft visually or by radar if so equipped. The use of laser designation equipment by any element increases the probability of that element being detected by any opposing element equipped with laser warning receivers (LWR), in that the LWR equipped system is presumed to know exactly the direction in which to search for the lasing system. The use of radar by any element increases the probability of that element being detected by any opposing element equipped with a Radar Warning Receiver (RWR) in that the RWR equipped system is presumed to know exactly the direction in which to search for the radar equipped system. The visual detection process allows for multiple observers for any element, and a horizontal and a vertical search distribution for all elements. Air defense forces may detect other ground weapons platforms by visual means only. In any case if an element is fired at by an opposing element then the firer is detected

immediately by the targeted system if it is in the sector of search of the targeted system. A discrete time-stepped search effort is conducted periodically by all units with detection events being scheduled to occur continuously throughout the remainder of a time interval. The time interval is a user input.

When a detection event occurs intervisibility between the observer and the detected target is again checked. If either the target is no longer visible to the observer or if the target is beyond maximum detection range then the detection is not allowed to occur.

The user may choose for any element whether or not that element's detections are to be shared with members of his section or platoon.

C. TARGET SELECTION

The mechanics of the target selection process in STAR-AIR is essentially unchanged from that of STAR, with the exception that selection of multiple targets is allowed. The firer will select his target of highest priority as a function of the range to prospective targets and the weapon types of prospective targets. Selection is limited to those targets which have been detected by the firer and to which line of sight still exists. Target priorities are determined from an element's target selection array which is input by the user. This array consists of three range bands which are defined as follows: less than 1000

meters, between 1000 and 2000 meters and greater than 2000 meters. Each weapon type - system type is assigned a priority within each range band. When two targets of equal priority are considered for selection the target which is closest in range to the firer is selected. Target selection fire control may be employed in a specific section or platoon independent of all other sections or platoons. If fire control by section (platoon) is chosen for a given element then that element will not select any target which is currently being engaged by another element of the same section (platoon). If all of this element's detected targets are being engaged then it will engage its highest priority target regardless of the fire control specified.

D. FIRING

For aircraft, command guided munitions may be fired by either direct or indirect firing techniques, the latter case requiring another element to remotely guide the round to the target. Guidance may be either continuous until impact or may revert to on-board missile guidance at a fixed distance from the target.

For the AAH/ASH team the user must specify one of three modes of operation. In Mode = 0, indirect rapid fire is employed as follows. All AAH's of a platoon are deployed 1 to 2 Km behind the positions of the ASH's and remain in defilade. The ASH selects from one to n targets, n being specified by the user. The ASH then selects the AAH with

the most command guided missiles remaining, and directs the AAH to fire missiles in the proper direction at the time increment specified by the user until each target has been engaged. In this mode even if a target is not a catastrophic kill the ASH will not reengage this target until all remaining targets that were selected for this engagement series have been engaged. After engaging the last target the exposed time of the ASH is checked. If the ASH is approaching his exposed limit (user input) then he masks otherwise another target selection is initiated.

In Mode = 1, direct ripple fire is employed. All AAH's and ASH's are deployed in forward positions of an attack area. Each ASH will team with an AAH. The ASH will select two targets and the AAH will fire two missiles in succession. As the ASH directs the first missile the AAH directs the second missile. Any AAH's not teamed with an ASH will target select and engage targets in accordance with the fire control specified. Each aircraft will mask and popup again in accordance with the EXPOSED.LIMIT and HIDE.TIME parameters which are input. In Mode = 1 operation, paired AAH/ASH teams will always mask and popup together.

In Mode = 2, autonomous direct fire is employed. Again all aircraft are deployed forward. The ASH's may share target information with the AAH's but the AAH will select its own targets. Any command guided munitions will be self-illuminated. All masking and popup will be done individually.

For fixed-wing aircraft, in particular the A-10, firing is limited to one target per pass over the target area. There are no limitations on the munition types to be represented, however, all target selection and firing is done autonomously.

All aircraft may have as a user selected option a mission abort criteria. If mission abort is chosen then whenever an aircraft detects that it has been fired upon it will immediately abort any mission in progress and will mask.

Air defense firing tactics allow for numerous user selected options. For gun systems the number of bursts and the burst size may be varied by type of target, either helicopter or fixed-wing and by target range. A ripple fire range and the number of rounds or bursts to be fired may be selected, resulting in a higher probability of kill for targets engaged within the specified ripple range. The user may specify a reload time for those systems which carry additional munitions on-board that are not in a ready to fire configuration. A system that has consumed all of its ready munitions will not be allowed to fire until reload has been accomplished.

For both aircraft and air defense forces refire tactics upon impact are available to the user as follows. If the target is not destroyed either no action, another target select or a refire of the same target may be selected. The

user also specifies the maximum number of times that the same target will be reengaged. If the target is destroyed either no action may be selected or another target selection may be immediately effected. For aircraft using popup tactics the exposed time since last masking is checked after every engagement. If the user input EXPOSE.LIMIT since last masking is being approached (within 10 secs) then a masking is effected rather than selecting one of the reengagement options discussed above.

E. IMPACT

For automatic weapons and fire and forget missiles every firing results in an impact and an assessment. However, for command guided missiles impacts are treated much differently. If a missile is command guided by the firer then the validity of the guidance is checked at a frequency specified by the user throughout missile flight until impact. If line of sight between the firer and the target is lost or if the firer is destroyed prior to impact then the missile is adjudged a miss. If the missile is command guided for part of its flight and then reverts to terminal homing a final check of the guidance is made at the point of guidance change and all subsequent checks are made at impact.

For the case of indirectly fired missiles guided by a remote source such as an ASH the above checks are conducted but an additional check is made to determine that the missile

was successfully acquired by the remote illumination source. All validity checks are then made with the ASH as if it were the firer, that is, line of sight between the ASH illuminating the missile and the target is checked as well as the alive/dead status of the ASH. All Air Defense missiles are evaluated in the same way as the aerial missile systems depending only upon the characteristics of the missile.

At the present time accuracy and lethality computations are done in a simplified manner as a function of range to the target. Upon receipt of data to support these computations more realistic computations will be performed for both accuracy and lethality.

F. AIRCRAFT MOVEMENT

Movement for air defense elements in STAR-AIR is performed in the same manner as for all other ground elements including redeployment and movement to alternate positions. Manportable air defense systems (MANPADS) such as the Stinger or SA-7 are moved with the designated troop carrier or BMP. The user should refer to Ref. 11, Naval Postgraduate Technical Report, for further information concerning Air Defense movement. The user designates which systems must stop to engage targets and which systems are allowed to fire on the move.

All aircraft movement is done along preplanned routes from rear bases to forward areas and along temporary routes from the forward areas to specific attack positions.

Helicopters operating in a popup mode of attack may be redeployed from indirect fire positions to direct fire positions but once a helicopter is in position no actual movement is accomplished. Instead, the helicopter's height above ground is varied to simulate popping up to engage targets and popping down again for cover and concealment.

Fixed wing aircraft are represented in an attack area as flying along an orbiting route which terminates at a preplanned attack position from which targets are acquired and engaged. If a target selection is made by a fixed wing aircraft a temporary attack route is dynamically constructed and, after the aircraft breaks off the attack, another temporary route is constructed to return the aircraft to its orbiting path for another target selection.

Joint Air Attack Teams (JAAT) may be represented in which case all deployment or redeployment of the JAAT team is done as a team, including returning to their respective bases for rearming and refueling. The JAAT team will return to base when either flight's time in the air has expired or when both flights' ammunition expenditure levels have been reached, whichever occurs first.

Resupply by air and general purpose flights may be accomplished along preplanned routes except that only one stop may be made at the end of the route at which point the aircraft will return to base along the same route.

Flights of aircraft operating as a maneuver force may be represented as well as a fire support force. In the case of

maneuver, all redeployment orders are generated in the same manner as for the ground forces.

The user may specify for any given mission whether targets of opportunity may be engaged while the flight is in route to an attack area. Non-combatant aircraft may detect targets and be detected. Such aircraft may also be armed with either air to ground or air to air munitions.

G. REDEPLOYMENT

Redeployment of attack aircraft for BLUE forces from one attack area to another may be accomplished to support ground force's requests in accordance with the current tactical situation. Those flights designated as fire support may be deployed or redeployed to any preplanned attack area while those designated as maneuver forces may deploy only to those attack areas preplanned for maneuver forces. RED forces will deploy forward along a single route from one attack area to the next in accordance with the maneuver scheme of the accompanying ground forces. All RED aircraft redeploymnet is triggered by the average number of detected targets in the target lists of the aircraft of a flight falling below a user input threshold. For example, if 2 had been input as the threshold then the RED flight supporting the attack would redeploy forward to the next preplanned attack area along the axis of advance if the average number of detected targets in the target

lists of the aircraft of that flight fell below 2. The user may implement any desired deployment scheme such as the one-third rule wherein one-third of the available air assets are in the target area at all times while the remaining aircraft are en route or refueling and rearming.

At the start of the simulation, flights of aircraft may be placed at rear bases or in forward attack areas as the user desires. Aircraft may not be placed along a route at the start of simulation. All members of a JAAT team that are placed in attack positions at the start of the simulation must be placed in the same attack area. However, JAAT team members need not be based at the same airfield.

H. BLUE AIR AUGMENTATION

The user may represent non-organic air augmentation for specific types of aircraft or for JAAT teams by designating Corps Air Augmentation as available. A brigade order for maneuver battalions to redeploy will generate a request for air augmentation to the three attack areas that support the three maneuver battalions. If Corps Air Augmentation is available then all three attack areas will receive air support. If Corps Air Augmentation is not available then only those organic flights of aircraft available at rear bases will be committed and the designation of ground areas to receive air support is determined by the weighting scheme and priorities input by the user in the ground model. For a discussion of these weighting schemes and priorities see ref. 11.

III. PROGRAM INPUT VARIABLE DEFINITIONS

A. INTRODUCTION

This chapter outlines the data input requirements and fully defines all variables and data arrays that must be input. It is hoped that the reader, through reading the definitions of the input variables described herein, will develop a better understanding of the model capabilities as well as an appreciation of the level of detail and the flexibility afforded in the choice of tactics and the values of many key parameters.

Appendix C contains the actual values used in the sample simulation described in Chapters IV and V. The data is unclassified and is solely used to exercise the model. No conclusions should be inferred from the data as to weapon system capabilities or limitations.

In general all data values may be input in free field format meaning that specific columns of a computer card or data storage record need not be used for specific values except that each entry must be separated by at least one blank space. Integer values must be input without decimal points. Zeroes must be input where applicable. Real values may be input with decimal points or, for whole numbers, without decimal points.

The order of presentation of the input variables and arrays corresponds to the sequence in which they are read in by the program.

B. DESCRIPTION OF VARIABLES INPUT BY ROUTINES MAIN AND INITIALIZE

The variables described in this section are read in by routines MAIN and INITIALIZE. The actual values used for the sample simulation can be found at Table X of Appendix C.

AIR.ADA - An integer global variable which identifies the input device to be used to read in all STAR-AIR input. This variable must be read by the MAIN program as it is used to identify the input device to the other STAR-AIR routines.

AIR2.ADA - An integer global variable which identifies the output device to be used to output the results of the simulation.

IN.ECHO - An integer global variable which must be input as a zero or one. A zero value will suppress the output of all input data while a value of one will cause all input data to be echo printed after it is read by the program.

AC1ADA, AC2ADA - Integer local variables which identify the starting number and the final number for the BLUE air defense and aircraft units to be input. All BLUE air and ADA forces to be simulated must be input in consecutive order with the first given name AC1ADA and the last given name AC2ADA. The aircraft which may be used as Corps Air Augmentation must not be included in this group. For the sample simulation AC1ADA and AC2ADA are 1 and 34 respectively indicating that the BLUE forces are numbered consecutively from 1 to 34.

AC3ADA, AC4ADA - Integer local variables which identify the starting number and the final number for the RED air defense and aircraft units. Again, all numbers must be consecutively input starting with AC3ADA and ending with AC4ADA. There is no allowance for RED Air Augmentation. For the sample simulation AC3ADA and AC4ADA are 35 and 73 respectively.

R.NUM.ALIVE - An integer global variable which is the total number of RED elements to be represented.

B.NUM.ALIVE - An integer global variable which is the total number of BLUE elements to be represented.

DELTA.T - A real global variable representing the time interval in seconds between successive schedulings of the event STEP.TIME. Event STEP.TIME initiates the ground to ground detection process.

N.COMPANY.COMMANDER - An integer global variable that represents the total number of companies, RED and BLUE, that will be represented.

N.PLATOON.LEADER - An integer global variable that represents the total number of platoons, RED and BLUE, that will be represented.

SUBNAME - An alpha-numeric array in which the abbreviated names of program subroutines are stored. SUBNAME is used with the diagnostic or trouble shooting logic.

QQ - An alpha-numeric array in which the abbreviated names of each weapon type is stored. QQ array is used in

printing the results of engagements to aid in quickly identifying weapon types.

C. DESCRIPTION OF VARIABLES INPUT BY ROUTINES B.FORCES AND R.FORCES

The variables read in by routines B.FORCES and R.FORCES are the attributes that must be read in that describe the individual elements in the simulation. Routine B.FORCES creates each BLUE element and assigns the input value to the attribute variables listed below. Routine R.FORCES does the same for the RED forces. The actual values used for the sample simulation can be found at Table XI in Appendix C.

The required data input for any air or ADA element is described below. Those attributes which have been bit packed to save core storage are indicated by an asterisk, followed by a number which indicates the largest possible value allowed. Numbers larger than those indicated will be truncated by modular arithmetic and only the remainder form will be stored. All input attributes are integers.

NAME (*2047) - The sequence number of the element. Within each group of elements created the names must be input sequentially. Errors will cause program execution to cease and an error message will be printed.

COLOR(*1) - A 1 indicates a BLUE element and a Ø indicates a RED element.

SYS.TYPE(*153) - The system type for the element. Type = (3) identifies manportable Air Defense weapons, Type = (6) identifies all other Air Defense weapons and Type = (5) identifies aircraft. See Table I in Chapter II for all other SYS.TYPE codes.

WPN.TYPE(*127) - The weapon type within the given system type of an element. For System Type 3, the manportable ADA weapons must be the first weapon types for the carrier reload logic. See Table I in Chapter II for all other WPN.TYPE codes.

SEC(*3) - The numerical section designation for an element, maximum of 3 sections per platoon.

PLT(*511) - The numerical platoon designation for an element. Must be consecutively numbered with no duplication.

CO(*255) - The numerical company designation for an element. Must be consecutively numbered with no duplication.

BN(*31) - The numerical battalion designation for an element.

COCDR(*2047) - The name (sequence number) of this element's company commander. The company commander must be input prior to inputing any members of his company.

PLTLDR(*2047) - The name of this elements' platoon leader. The platoon leader must also be the first element of his platoon that is input.

SECLDR(*2047) - The name of this element's section leader. Again, the section leader must also be the first

element of his section input. For model purposes a company commander must also be his own platoon leader and section leader. Likewise a platoon leader must also be his own section leader.

MODE(*7) - The attack mode which designates which helicopter tactics are to be employed. Mode = 2 designates autonomous operations while Mode = 1 designates ripple fire of command guided munitions and Mode = 0 designates indirect rapid fire with another element guiding the round from a direct fire position.

VEH.TYPE(*15) - A code number used by basic STAR to identify the vehicle type for a given weapon system.

PROLE(*3) - The primary role of the element. A PROLE = (1) identifies all ADA elements, A PROLE = (2) identifies all aircraft, and A PROLE = (0) identifies all other ground elements.

MROLE(*7) - The mission role of an aircraft. AN MROLE = (0) identifies combat aircraft either at a base or to be initially placed in a forward attack area. AN MROLE = (7) identifies all other aircraft such as supply, remotely piloted vehicles or administrative vehicles. No other MROLE values may be input. MROLES of 1 through 6 are dynamically set and changed during the simulation to identify the aircraft mission status. The following is a definition of these MROLEs.

AN MROLE = (1) identifies aircraft en route to an attack area.

AN MROLE = (2) identifies aircraft returning to base from an attack area.

AN MROLE = (3) identifies an aircraft employing popup tactics in an attack area.

AN MROLE = (4) identifies an aircraft that has arrived at the control point associated with an attack area and is deploying to its attack position within that attack area.

AN MROLE = (5) identifies an aircraft employing run in dynamic attack tactics.

AMMO1(*127), AMMO2(*255), AMMO3(*4095), and AMMO4(*4095) - The initial ammunition load for ammunition types 1, 2, 3 and 4 respectively. Only Air Defense elements need ammunition loads to be input. For aircraft the initial load will be initialized by routine RESUPPLY.

NO.OBS(*7) - The number of visual observers that are actively engaged in the target acquisition process. For an aircraft with 3 crew members that might be 1, 2 or 3 depending on the duties of the crew.

CG.MUNITION(*1) - Designates AMMO type 1 as being a command guided munition when initialized to one. A zero implies AMMO1 is not command guided. Only AMMO1 may be command guided or command guided, terminal homing.

RADAR(*1) - A one identifies those elements equipped with acquisition radars. A zero indicates no radar equipment.

VAREA(*511) - The visual area of search for all aircraft and air defense except for those long range air defense

systems without visual observers in which case VAREA is the radar area of search. The area must be input in degrees and cannot exceed 360°.

THERMAL(*1) - A one identifies those elements with thermal imaging equipment while a zero indicates no thermal equipment for target acquisition purposes.

RWR(*1) - A one indicates those aircraft with radar warning receivers. A zero indicates no radar warning receivers.

LSS(*1) - A one indicates elements equipped with laser spot seekers while a zero indicates no laser seekers.

LSD(*1) - A one indicates a laser designator/illuminator while a zero indicates no laser designater.

BASE(*127) - All aircraft must be assigned a base or airfield number which corresponds to the number of a pre-planned base area.

POS.IN.PLT.AREA(*31) - The position in the platoon area for a specific element, allows for dispersement of aircraft at bases as well as preplanned attack positions for each aircraft.

LWR(*1) - A one indicates elements equipped with laser warning receivers while a zero indicates no laser receivers.

DET.SEC(*1) - A one indicates that this element will share all detections with other members of his section. A zero will preclude sharing detections.

DET.PLT(*1) - A one indicates an element will share all detections with other members of his platoon. A zero will preclude sharing detections. If DET.PLT is set to 1 then DET.SEC should be set to 0 to avoid unnecessary computations since every element in a given section must also be in the same platoon.

SEL.SEC(*1) - A one indicates that section fire control will be implemented by a given element. A zero indicates no section fire control.

SEL.PLT(*1) - A one indicates that platoon fire control will be implemented. As above for the detection sharing only one of the two fire control plans should be set to one for any given element.

MSN.ABORT(*1) - A one designates those aircraft which will abort a mission in progress, seeking cover immediately, once the element detects it has been engaged.

POP.UP(*1) - A one designates helicopter popup tactics are to be employed. A zero indicates that dynamic attacks will be employed.

D. DESCRIPTION OF VARIABLES INPUT BY ROUTINE TEMP.GRD.POS

The variables read in by routine TEMP.GRD.POS deal with the position attributes of all ground systems to include Air Defense. The actual values used for the sample simulation can be found at Table XII, Appendix C. Aircraft position information is read in by routines AIR1.INIT and AIR2.INIT which are discussed in Sections E and F of this

chapter. The position attributes read in by routine TEMP.GRD.POS are as follows:

X.CURRENT - An element's X coordinate.

Y.CURRENT - An element's Y coordinate.

SPD - The speed at which the element will travel.

PR1.DIR - The element's primary direction of search.

DIR.OF.MVMT - The element's direction of movement.

It should be noted that when STAR-AIR is incorporated with basic STAR the input of the above five position attributes is done by other routines of STAR so routine TEMP.GRD.POS will not be utilized.

E. DESCRIPTION OF VARIABLES AND ARRAYS INPUT BY ROUTINE AIR.1INIT

The variables and arrays described in this section are read in by routine AIR1.INIT. The actual values used for the sample simulation are found at Table XIII, Appendix C.

NO.ATK.AREA - An integer, global variable designating the total number of both BLUE and RED preplanned attack areas, to include assembly areas and bases.

NO.POS - An integer variable which designates for each attack area the number of preplanned attack positions within that attack area. Attack positions are sequenced from 1 to NO.POS for each attack area with the position number in the attack area corresponding to the temporary attribute of an aircraft, POS.IN.PLT.AREA, the aircraft's position in platoon area. For any given aircraft the

position number input (POS.IN.PLT.AREA) will determine the position that this aircraft will occupy in any attack area to which it deploys. As an exception, a BLUE attack helicopter may redeploy once from its indirect fire position to a direct fire position, after which it will always occupy the direct fire position.

L - An integer, local variable used to check the input sequence of attack positions.

ATK.POS(I,J) - Real, 2-dimensional global arrays, one per attack area, with I varying from 1 to 4 and J varies from 1 to the NO.POS for each attack area. An example of an attack position input follows:

```
        1        (NO.ATK.AREA)
        2        (NO.POS)
        1  4500  1600  37.5  0.    (Position No. 1)
        2  4700  1625  18.7   .252(Position No. 2)
```

In this example one attack area is specified with 2 attack positions. Position No. 1 is located at X-coordinate 4500 and Y-coordinate 1600. The height above the ground (or ground and trees, if trees are present) for target acquisition is 37.5 meters and the primary direction or angle is 0 radians. The attack position array for this attack area would then be stored as follows.

4500.	4700.
1600.	1625.
37.5	18.7
0.	.252

The pointer value for each attack position is stored in an array called ATK.AREA and is accessed by the attack area number. Therefore, it is necessary to input at least one attack position for each attack area. Secondly, all attack areas must be sequentially numbered starting with one.

ATK.ROUTE(I,J) - An integer, 2 dimensional global array containing the route numbers and final control points for the associated route for aircraft movement from base to attack areas and return. An example follows:

	1	2	3	(Attack area number)
1	1	2	5	(Route)
2	1	7	15	(Control point)

To reach attack area 3 the appropriate route is route 5 and the final control point for this attack area along route 5 is 15.

ZEROL - A real global variable which is used as a mathematical convenience to redefine very small numbers as zero. A typical value used is .0000001 which is then used to test numbers in absolute value. A number smaller than the above is considered to be zero.

AC.DELTA.T - A real, global variable which is the time interval between successive target acquisition events (Event AC.STEP.TIME) for aircraft detection of ground or air elements and for all ground elements detecting aircraft. AC.DELTA.T should be smaller than DELTA.T which is

the corresponding ground-to-ground time interval for detecting events but should not be smaller than 5 seconds. A typical value used is 10 seconds.

MNDRNG - A real, global variable within which any element is presumed to automatically detect any opposing element to whom line of sight exists. A typical range of values is 100 to 500 meters.

MXDTIME - A real, global variable greater than 30 seconds used to preclude scheduling of detection events for elements when the computed time to detect is large. A typical value is 99 seconds.

MNDTIME - A real, global variable used as the detection time for all detections resulting from automatic detections for minimum detection range.

PVG, PVM, PVH - Real, global variables defining the percentage of visual vertical search effort expressed as a fraction expended for ground level, medium level and high level search respectively. The sum of PVG, PVM and PVH must equal 1. Values for the sample battle simulated are .6, .3 and .1 respectively.

R.MIN, R.MED - The vertical angle measured from horizontal separating the ground level to medium and the medium level to high altitude search effort. Since a discrete visual search effort includes a 30° angle R.MIN and R.MED should be 30° apart. Both angles are input in degrees and then converted to radians. Values for the sample battle simulated are 15 and 45 degrees respectively.

N1WPNS - An integer global variable indicating the total number of weapon systems with PROLE of 1; that is, air defense.

N2WPNS - An integer global variable indicating the total number of weapon systems with PROLE of 2; that is, aircraft.

AIR.SPEED(I,J) - A real, 2-dimensional array where I ranges from 1 to 4 and J varies from 1 to N2WPNS. For each aircraft weapon type the user must assign 4 values. The first value is the estimated aferage cruising speed for level flight. The second value is the estimated average climbing speed for vertical or near vertical flight. The third value is the positive, estimated minimum speed for flight at near zero altitude above ground level; for example, the average speed of a helicopter following a nap of the earth flight plan at the treetops or in the trees. Finally, the fourth value is the minimum altitude for which the average horizontal flight speed can be maintained. An example of the AIR.SPEED values for the AAH is as follows:

	1	Weapon type <u>Explanation</u>
1	120	120 meters/second horizontal
2	25	25 meters/second climbing
3	15	15 meters/second minimum
4	7	7 meters minimum altitude for 120 meters/second horizontal speed

AMMOLOAD(I,J) - An integer 2-dimensional global array with I ranging from 1 to 4 for the four ammunition types and J varying from 1 to N2WPNS for each aircraft weapon type. This array contains the values for the basic load of each aircraft weapon type.

AMMOFRCT(I,J) - A real 2-dimensional global array with I and J ranging as in AMMOLOAD. This array contains the fractional levels of the initial basic load of a given AMMO type weapon type which may generate a return to base event. For a given aircraft type all AMMO types with which the aircraft is armed must fall below this fraction for a return to base event to be generated. For mixed flights that contain two types of aircraft either aircraft type may generate a return to base for the entire flight. For JAAT teams both flights must meet the AMMO expended level before a return to base will be effected for ammunition expenditure. If an aircraft is not armed a return to base will not be generated. Similarly an armed aircraft in a mixed flight may be disregarded for an ammunition return to base by inputting all zero's in the appropriate columns of the AMMOFRCT array for that aircraft.

RDRMAXDRNG(I,J) - A real, 2-dimensional global array containing the values of the radar minimum detection range for aircraft and air defense elements. The first row applies to ADA while the second row applies to aircraft, in accordance

with the PROLE of the element. The columns of this array apply to the weapon type of the element. This convention will be adhered to for the other jagged arrays to follow. In each case the first row will contain N1WPNS entries and the second row N2WPNS entries.

RDRMAXDRNG(I,J) - A real, 2-dimensional global array containing the values of the maximum detection range capability of a system.

RDRMINALT(I,J) - A real, 2-dimensional global array containing the values of the minimum altitude for which a radar system may acquire targets at maximum range.

RDRAREA(I,J) - A real, 2-dimensional global array containing the values of the area (in degrees) of coverage of a radar system.

THMAXDRNG(I,J) - A real, 2-dimensional global array containing the values of the thermal maximum detection range of a system.

LSMAXDRNG(I,J) - A real 2-dimensional global array containing the values of the laser maximum detection range of a laser spot seeker (LSS).

THAREA(I,J) - An integer, 2-dimensional global array containing the values of the thermal detection devices area of converage (in degrees) for a system.

THSECT(I,J) - An integer, 2-dimensional global array containing the values of the thermal detection devices' angular sector (in degrees) for an instantaneous glimpse.

The THSECT value may be no larger than the THAREA designated. An example might be a system that has an area of 20 degrees over which a device may be directed and a sector of 5 degrees of view for any given direction.

FRRDRON(I,J) - A real, 2-dimensional global array containing values for the fraction of time that a given radar system is allowed to operate. If blinking of the radar is not desired then the input value should be 1.

F. DESCRIPTION OF VARIABLES AND ARRAYS INPUT BY ROUTINE AIR.2INIT

The Variables and arrays described in this section are read in by routine AIR2.INIT. The actual values used for the sample simulation can be found at Table XIV in Appendix C.

FIRSTAC,SECONDAC - Integer, global variables which assign positions in platoon areas for any non-popup aircraft such as A-10's. The platoon leader's section will deploy to position FIRSTAC while all members of the other section will deploy to position SECONDAC. If both BLUE and RED forces employ fixed-wing aircraft then all attack positios must be planned such that the dynamic attack positions are numbered the same for both forces.

ACACQHT - Integer, global variable which specifies the height above ground level to which fixed-wing aircraft will rise during the target acquisition phase of the orbit route. This value must be large enough to insure detections

may be made yet small enough to preclude unnecessary aircraft exposure to opposing ADA systems. A range of typical values would be from 35 meters to 75 meters.

AC.TIM.CRIT - A real, global variable which acts as a filter to preclude small aircraft movements for periods of time smaller than AC.TIM.CRIT. A typical value used is .5 seconds.

B.LAST.FWD.POS - An integer, global variable specifying the highest numbered forward attack position for all BLUE preplanned attack areas.

B.INDIRECT.COUNT - An integer, global variable specifying the total number of indirect firing positions for AAH aircraft. By way of example, if the largest platoon of helicopters contains 3-ASH's and 5-AAH's then the attack positions should be ordered as follows:

Positions 1, 2 and 3: Forward positions for ASH

Positions 4, 5, 6, 7, 8: Forward positions for AAH

Positions 9, 10, 11, 12, 13: Indirect positions for AAH

In this example B.LAST,FWD.POS is 8 and B.INDIRECT.COUNT is 5. If the AAH occupying position 9 is redeployed forward it will deploy to position 4, that is 9 - 5 (B.INDIRECT. COUNT).

NO.SORTIES - An integer, global variable describing the number of AIR.SORTIES to be input, excluding any potential Corps Air Augmentations. Every flight of aircraft is organized as a platoon for model purposes with either one

or two sections. Each platoon of aircraft is associated with one and only one AIR.SORTIE, a temporary entity which contains numerous attributes (in addition to the attributes of the elements) which describe the mission and limitations of those aircraft comprising the flight. AIR.SORTIES designated as JAAT are further cross-referenced with the AIR.SORTIE of the JAAT member. For each AIR.SORTIE planned the following data values (attributes) must be input.

NAM(*4095) - The sequence number or name of the AIR.SORTIE. Each AIR.SORTIE must be input sequentially and the sequence must start with 1.

AVL.TIME(*1048576) - The earliest time in seconds that this AIR.SORTIE is available to be launched. For implementation of the one-third rule available times may be staggered, to preclude an earlier launch of a platoon by the deployment/redeployment logic.

LDR(*4095) - The name of the platoon leader for this AIR.SORTIE's associated platoon.

LNCH.TIME(*1048575) - The scheduled time for this flight to be launched, barring an earlier deployment by the deployment/redeployment logic.

TOT.F.TIME(*65535) - The total flight time in seconds for this AIR.SORTIE including flight to and from the attack areas. This time will be used to generate a return to base.

HT.OF.FLT(*65535) - The height, in meters, that this flight will fly above the AIR.ROUTE sepecified for transiting to and from bases and attack areas.

EST.FLT.TIME(*65535) - An estimate in seconds of the time for this flight to transit one way from base to the most forward attack position. For deployment/redeployment considerations it should be noted that a return to base will be scheduled for an AIR.SORTIE in TOT.FLT.TIME minus two times the EST.FLT.TIME. time units.

TRN.A.TIME(*65535) - An estimate of the time required for rearming and refueling this flight after returning to base. An AIR.SORTIE will not be relaunched from its base until the amount of time indicated by TRN.A.TIME has expired.

COMPLEXION (*1) - A 0 indicates a RED sortie while a one indicates a BLUE sortie.

MIN.TIME(*65535) - The minimum amount of time that a BLUE sortie will spend in any given attack area before a redeployment is allowed to occur.

MAX.TIME(*65535) - The maximum length of time that a sortie will spend in a given attack area prior to redeployment to another attack area of equal criticality.

MIN.RNG(*65535) - A range within which a fixed number of opposing forces may trigger a redeployment to an alternate firing position or may trigger a mode change for attack helicopters from indirect to direct fire role.

MAX.NO(*127) - The critical number of opposing forces which will trigger the redeployment described above.

NO.AC1, NO.AC2(*15) - The number of aircraft of type 1 and 2 respectively which make up a mixed sortie.

NO. 1, NO. 2(*255) - The weapon type of the aircraft type 1 and 2 respectively.

JAAT(*4095) - The number (NAM) of the AIR.SORTIE that this AIR.SORTIE is teamed with. A zero indicates this flight is not a joint air attack team member.

FS.M(*1) - A zero indicates the mission of this flight is fire support while a one indicates a maneuver force. This is the final input attribute for an AIR.SORTIE. After the last AIR.SORTIE has been input the air missions must be input.

NO.MSNS - The number of air missions preplanned, up to a maximum of one per AIR.SORTIE input. If a mission is not input for a particular AIR.SORTIE then that sortie will remain at the base until a ground request for air support is received. All maneuver forces and general purpose flights must have a mission input. An exception to the above is that an attack flight with either a fire support or maneuver mission may be initially placed in an attack position, in which case no mission should be input for this flight. A mission which is input for a fire support flight may be changed by a higher priority air request received prior to the launching of the flight. If no air requests are generated a flight will continue to execute the last mission received after each return to base for rearm and refuel.

AREA - An integer variable describing the number of the attack area designated for a sortie.

NUMB - An integer variable corresponding to the sequence number (NAM) of the appropriate AIR.SORTIE.

MSN - An integer variable agreeing with the popup attribute of the aircraft in the flight. A zero indicates dynamic attack tactics and a one indicates popup tactics.

URG - An integer variable which when set to one will allow detections and engagements while en route to the objective area. A zero value will preclude such events from occurring during ingress to an attack area.

In the input sequence after the final mission has been input AIRREQUESTS may be input next. Although an AIRREQUEST is usually generated by the ground tactical situation AIRREQUESTS may also be input initially to exercise the deployment logic or to effect the corps air augmentation. All AIRREQUESTS are filed in a set ranked by highest criticality, then by lowest priority then by highest weight. The input variables and definitions are as follows.

N.AIRREQUESTS - An integer variable describing the number of AIRREQUESTS to be input.

TGT.POS - An integer variable containing the number of the ground area from which the request for air support is coming. This ground area number is converted by using the array AGLINK to the corresponding air attack area designated for support.

PRIORITY,WGHT - Integer values assigned by the ground forces planner for priority and then weight within priorities

for ground air support requests. For creating Corps Air Augmentation these values may each be input as one's.

MSN.CRIT - An integer variable indicating the criticality of the mission. A value of 5 will generate a corps air augmentation if one is available. If JAAT Corps Air teams are available a mission criticality of 5 will generate 6 Air Sorties with 3 teams consisting of one A-10 Air Sortie and one attack helicopter sortie for each team. If less than 3 air requests are input then the remaining air sorties will be available at their respective bases for deployment to other attack areas as air requests are generated by the BLUE ground forces.

CALLER - An integer variable describing the battalion seeking air support. For Corps Air Augmentation a value of one may be input.

After the last air request has been input (a zero must be input if no air requests are to be input) then the number of Corps Air augmentations available must be input. Although usually this will be one, more than one may be made available. The input sequence is as follows.

N.CORAIR - A global, integer variable indentifying the number of augmentations available. A total of three air sorties (six for JAAT teams) must be preplanned for each augmentation made available. If Corps Air Augmentation is not desired then a zero must be input and the next array is not read.

ACCOR - A 2-dimensional, integer array with one row for each Corps Air Augmentation available and two columns. In the first column the name of the platoon leader of the first Air Sortie must be input and in the second column the name of the last aircraft in the last sortie must be input. For example, if N.CORAIR is one then ACCOR might be

128   156

In this case BLUE element named 128 is the starting sequence number and 156 the ending number for creating the entities of the Crops Air Augmentation force. A call to routine B.FORCES(128,156) will be effected by the first Corps Air Augmentation request received.

STOP - A local integer variable which indicates the time that the user desires the simulation to stop. For example if the user inputs 4000 for STOP then the simulation would STOP at time equal to 4000 seconds.

NO.ROUTES - An integer, global variable describing the total number of permanent AIR.ROUTES to be input.

CP.NO - A local, integer variable describing for each route to be input the total number of control points for the route. Each control point has 4 values associated with it, namely the X, Y and Z coordinates and the height of flight for movement to the next control point.

B.BDE.ROUTE - An integer, global variable identifying the last BLUE preplanned route which is the route that crosses the BLUE defensive area connecting adjacent battalion assembly areas.

For each permanent route there are two or more preplanned attack positions, including assembly areas and bases. The LIST.ROUTE array stores the area and the final control point for that area for each route input. Consider figure 1 below.

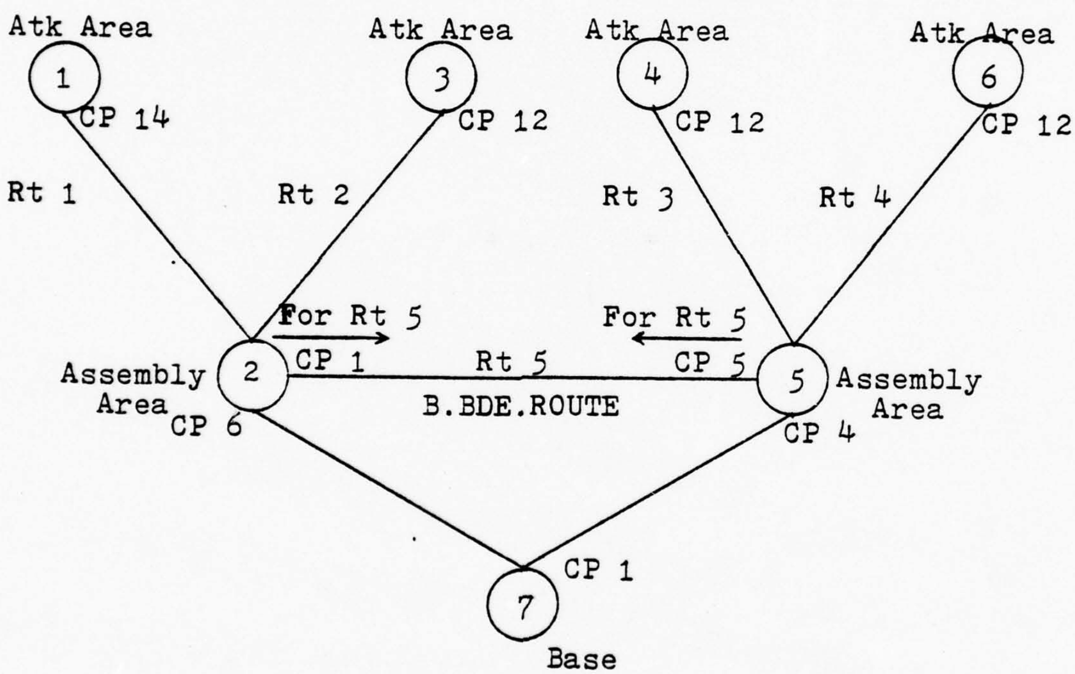


Figure 1 Preplanned Route Structure

In the example above there are 5 routes, with 1 to 4 beginning at a base and terminating at a forward

attack area. Route number 5 connects assembly area 2 and assembly area 5. For this example the input sequence for the LIST.ROUTE array is as follows:

3		(NO.POS for route 1)
1	14	(Area 1, final CP 14)
2	6	(Area 2, final CP 6)
7	1	(Area 7, final CP 1)

The remaining levels of the LIST.ROUTE array are presented in condensed form.

3	3	12	2	6	7	1	(Route 2)
3	4	12	5	4	7	1	(Route 3)
3	6	12	5	4	7	1	(Route 4)
2	2	1	5	5			(Route 5)

Note that B.BDE.ROUTE, Route Number 5, has only 2 positions connecting area 2 and area 5. The final control point for area 2 along route 5 is CP number 1 while the final control point for area 5 along route 5 is CP number 5. All other routes are planned from the base to the attack areas, thus the final control point for the base is the same for all routes.

NODE.NET(I,J) - A 2-dimensional, integer array with I ranging from 1 to the number of BLUE permanent routes and for each I, J ranges from 1 to the total number of attack areas and assembly areas that are connected by intersecting

routes at an assembly area. For the example given in figure 2, the NODE.NET array input sequence is as follows.

3	1	2	3	(Route 1)
3	3	2	1	(Route 2)
3	4	5	6	(Route 3)
3	6	5	4	(Route 4)
2	2	5		

The first line above of data values indicates that an area on route 1, namely area 1 connects with assembly area 2 and that area 2 also connects with area 3. Note that alternating rows are identical except that the order is reversed. For the brigade route, route 5, the NODE.NET array indicates that area 2 and area 5 are connected assembly areas.

The LIST.ROUTE array and the NODE.NET array are used in particular for redeployment of BLUE aircraft between attack areas. If a flight must redeploy from area 1 to area 6 then a temporary route will be created linking route 1 from CP 14 to CP 6, then route 5 from CP 1 to CP 5, and finally route 4 from CP 4 to CP 12.

STEP.AIR - A global, real variable whose magnitude determines how closely a dynamically generated flight path will trace the contour of the terrain over which the aircraft is flying.

AC.RDCHECK.TIME - A global, real variable specifying the time in seconds between successive redeployment checks for all redeployable aircraft. A typical value used is 100 seconds. This value must never be less than AC.DELTA.T

NUM.AREAS - An integer variable describing the number of BLUE preplanned ground defensive positions. For each preplanned ground defensive position there must be one air attack area specified. The same air attack area may be specified for more than one ground position but this may result in more than one aircraft occupying a single attack position.

AGLINK(I,J) - A 2-dimensional integer array with J ranging from 1 to NUM.AREAS with I ranging from 1 to 2. The ground defensive position number is input followed by the air attack area number. For example, 112 1 indicates that ground position number 112 is supported for air attack from air attack position number 1. Neither the ground nor air position numbers need be sequenced provided that pairs are input.

R.COUNT - A global, real variable specifying the trigger level for forward redeployment of RED aircraft. A platoon of RED aircraft will redeploy to the next forward position if the average number of detected targets is below R.COUNT during a redeployment check. This value must be greater than 1 (if redeployment forward is desired) since the target list size is one even when no detections have been made. A typical value is 1.5. For more rapid redeployment a larger value may be specified.

SPACE.TIMEAC - A global, real variable which specifies the initial spacing, in seconds, between fixed-wing aircraft

orbiting about the same attack position. A typical value used is 10 seconds.

G. DESCRIPTION OF VARIABLES AND ARRAYS INPUT BY ROUTINE AIR3.INIT

The variables and arrays described in this section are read in by routine AIR3.INIT. The actual values used in the sample simulation are found at Table XV in Appendix C.

REACT.TIME - Global real variable used in routine AIR.TACTICS. REACT.TIME, used in MODE = 0 rapid indirect fire, is the time interval representing the reaction time required by a remote illuminator between missiles fired in rapid succession. For example if REACT.TIME was equal to 5 seconds then if an ASH in MODE = 0 operation had selected 3 targets then the AAH attack team member would fire 3 missiles with a delay of 5 seconds between each.

GUID.OFF - Global real variable used in routine LASER.HANDOFF and event AC.VALIDITY.CHECK. For command or laser guided missiles it is the small increment of time, just before impact, during which, if guidance is lost, the missile would still hit the target. The last guidance validity check is made at GUID.OFF units before impact.

TERM.GUIDE.TIME - Global real variable with same function as GUID.OFF in routine LASER.HANDOFF and event AC.VALIDITY. CHECK. It is used for terminal guided missiles that are command guided for the first segment of flight and then

revert to terminal homing during the final segment of flight to impact.

LASER.LOCK.PCT - Global real variable used in event AC.VALIDITY.CHECK. It is a number between zero and one representing the percentage of time that a laser guided missile is expected to lock onto the laser beam of a remote illuminator.

HIDE.TIME - Global real variable used in event AC.HIDE. It is the amount of time that a popup aircraft will remain in defilade when it hides.

EXPOSED.LIMIT - Global real variable used in numerous routines. It is the amount of time a popup aircraft will remain exposed before masking or going in to defilade. Aircraft will not necessarily be exposed for exactly HIDE.TIME units as a firing in progress is allowed to continue to impact even if EXPOSED.LIMIT is exceeded. In this case a hide would be scheduled immediately upon impact if a command guided munition was fired or upon completion of event FIRE for non-guided munitions.

NUM.RIPPLE - Global integer variable. The maximum number of missiles to be fired by an attack helicopter employed in a rapid indirect fire, (MODE = 0) engagement.

MFCT - Global real variable. The Missile Flight Check Time (MFCT) interval is the frequency at which AC.VALIDITY. CHECK events are scheduled for command guided munitions, i.e., a guidance validity check is made every MFCT units until GUIDE.OFF or TRM.GUIDE.TIME units before impact.

ADA.ARRAY - A 2-dimensional integer array in which Air Defense Methods of Fire variables are stored for each type of air defense element represented. The number of rows is read in as the variable N.AD.SYS, which should correspond to the number of Air Defense system types being simulated. The number of columns is read in as the variable N.AD.COLS, which should be 13. A diagram of a typical row of the ADA array is shown in Figure 2 and a discussion of the entries follows:

Columns 1 & 2 indicate the SYS.TYPE and WPN.TYPE of a ZSU air defense gun.

Column 3 indicates 2 bursts will be fired at helicopters.

Column 4 indicates a burst size of 30 rounds will be fired at helicopters.

Columns 5 & 6 same as 3 & 4 except for fixed wing aircraft.

Columns 7 & 10 indicate that inside a range of 500 meters ripple fire consisting of 4 bursts will be fired at helicopters.

Column 8 contains the same information as column 7 except for fixed wing aircraft.

Column 9 indicates the average time interval in seconds between bursts fired for an automatic gun system or between missiles fired for a missile system. In figure 2 a time interval of 1 second is indicated.

Column 11 indicates that there are 1000 rounds stored in a ready configuration and when those rounds have

	1	2	3	4	5	6	7	8	9	10	11	12	13
ZSU	6	9	2	30	4	15	500	800	1	4	1000	-	120
SA-9	6	6	1	1	1	1	1000	1500	1	1	4	-	300

Column 1: SYS.TYPE Code

Column 2: WPN.TYPE Code

Column 3: Number of bursts to fire at helicopters

Column 4: Burst size to fire at helicopters

Column 5: Number of bursts to fire at fixed wing aircraft

Column 6: Burst size to fire at fixed wing aircraft

Column 7: Range for ripple fire at helicopters

Column 8: Range for ripple fire at fixed wing aircraft

Column 9: Time between bursts

Column 10: Number of bursts to fire in ripple fire

Column 11: Number of rounds until reload

Column 12: Currently not used

Column 13: Reload time

Figure 2 ADA.ARRAY - Air Defense Methods of Fire

been expended the ZSU will have to withdraw from the battle to transfer on-board ammunition from a stored to a ready configuration.

Column 12 not used at this time.

Column 13 indicates that 120 seconds is needed to reload or transfer on-board ammunition from a stored to a ready configuration.

H. DESCRIPTION OF ARRAYS INPUT BY ROUTINE DANGER.STATE

Routine DANGER.STATE, called by routine AIR3.INIT, reads the arrays POINT.HOLD and ARRAY which are described in this section. The actual values used in the sample simulation are found in Table XVI in Appendix C.

POINT.HOLD - A two-dimensional integer array that contains tactics and firing information for each weapon type.

ARRAY - A two-dimensional integer array which is described in Chapter II and further described below. A target selection ARRAY is stored for each weapon type represented.

A diagram of POINT.HOLD which has been extracted from ref. 11 is shown below:

	3	4	5	6	7	8				9				10	11	12	13	14
	1	1	*	9	3000	2600	2600	1200	0	1598	921	604	0	1	1	1	30	3
1																		

2

1. NUM.DS.ARRAYS: The number of rows of array POINT.HOLD and the number of ARRAYs to be created.
2. WD: The number of columns of array POINT.HOLD.
3. Column 1: SYSTYPE: The system type of the firer under consideration.
4. Column 2: WPNTYPE: The weapon type of the firer under consideration.
5. Column 3: The storage location of the pointer to the given system/weapon type's target selection ARRAY.
6. Column 4: The target selection crew drill number for this system/weapon type (used only for non-air defense ground systems).
7. Column 5: The maximum acquisition range in meters for the system/weapon type.
8. Columns 6-9: The maximum opening range in meters for ammunition types 1 through 4.
9. Columns 10-13: The muzzle velocities in meters per second of ammunition types 1 through 4.
10. Column 14: A 1 indicates all ammunition types may be fired on the move. A 0 otherwise (e.g., those system/weapons with ATGM).
11. Column 15: The WE.HIT tactics number used in routines WEHIT.AIR for air and air defense elements and routine WE.HIT for ground elements to identify the tactic to be used after a successful firing

engagement. For air and air defense elements the following codes are used:

Code		Action
1	-	Select another target
0	-	No action

12. Column 16: The WE.MISS tactics number used in routines WEMISS.AIR for air and air defense elements and routine WE.MISS for ground only elements to identify the tactic to be used after an unsuccessful firing engagement. For air and air defense elements the following codes are used:

Code		Action
1	-	Select another target
2	-	Refire on the target that was missed
0	-	No action

13. Column 17: Time in seconds to remain in full defilade after a WE.HIT/WE.MISS sequence (currently not used for air and air defense elements).

14. Column 18: For ground only elements; alternate ammunition type for use in routine TACTICS. For air and air defense elements; the maximum number of times that are element is allowed to refire at a missed target.

An example of an ARRAY (Target Selection array) for a system type 5, weapon type 1 (an attack helicopter) is shown below:

0 - 1000 meters	6	9	3	1	6	6	1	1	6	6	2	3
1000 - 2000 meters	6	9	13	1	6	6	11	1	6	6	12	3
> 2000 meters	6	9	23	1	6	6	21	1	6	6	22	3

The first row represents the 0-1000 m range band and has 3 blocks of 4 numbers. The first 4 numbers indicate that system type 6, weapon type 9 has a priority 3 using ammunition type 1 within this range band. Thus numbers are read in the following order:

System type of target

Weapon type of target

Priority of this target

Ammunition type to be used against this target.

Moreover, within system/weapon types, if more than one priority is to be assigned within a range band, the blocks of 4 numbers should be contiguous and the priorities increasing to the right. A glance at the first row information for system type 6, weapon type 6 should convey the idea.

If a firer may not engage targets in a given rangeband, a row of 4 zeros (0 0 0 0) should be input for that rangeband.

Since POINT.HOLD and ARRAY are filled in one operation, some sample input for both arrays is shown (letters are keyed to the explanation below):

a b

7 16

c d e f

2 3 8 3500 $\overbrace{3000\ 0\ 1500\ 0}^{g}$

$\overbrace{217\ \ 0\qquad 1132\ \ 0}^{h}$

i j k_1 k_2 k_3

0 3 3 20 3

ℓ

3 $\overbrace{1\ 7\ 3\ 1\qquad 2\ 8\ 1\ 3\qquad 2\ 8\ 2\ 1}^{m}$

n

3 $\overbrace{7\ 11\ 1\qquad 2\ 8\ 12\ 1\qquad 2\ 8\ 13\ 3}^{o}$

p

2 $\overbrace{1\ 7\ 21\ 1\qquad 2\ 8\ 22\ 2}^{q}$

a. NUM.DS.ARRAYS

b. WD

c. SYSTYPE (Column 1 of POINT.HOLD)

d. WPNTYPE (Column 2 of POINT.HOLD)

e. Target selection crew drill number (Column 4 of POINT.HOLD)

f. Acquisition range (Column 5 of POINT.HOLD)

g. Opening range of ammo types (0 indicates ammo type is not available). (Columns 6-9 of POINT.HOLD).

h. Muzzle velocity of ammo types (0 indicates ammo type is not available. (Columns 10-13 of POINT.HOLD)

i. Fire on move capability (Column 14 of POINT.HOLD)

j. WE.HIT tactic number (Column 15 of POINT.HOLD)

k_1. WE.MISS tactic number (Column 16 of POINT.HOLD)

k_2. Defilade time

k_3. Alternate ammo for use in routine TACTICS

ℓ. Number of 4 number blocks of target selection information to be entered in the 0-1000 meter rangeband.

m. The 0-1000 meter rangeband target selection information.

n. As in l, except for 1000-2000 meter rangeband.

o. As in m, except for 1000-2000 meter rangeband.

p. As in l, except for > 2000 meter range band.

q. As in m, except for > 2000 meter range band..

A block of data in the manner described by c through q is to be input for each system/weapon under consideration.

IV. SAMPLE SIMULATION PLAN

A. INTRODUCTION

This chapter discusses the forces represented, the tactics employed by the air and air defense elements and the key parameter inputs for the sample simulation presented in this and the following chapter. The simulated battle presented herein is a typical simulation using the STAR-AIR model, however only one set or combination of the many tactics, deployment schemes and fire control methods that the user has to choose from is demonstrated.

Since this is a demonstration of the Air/Air Defense model the ground routines of STAR are not included so consequently the non-Air Defense ground elements only occupy positions and move across the battlefield to serve as targets for the air elements.

B. FORCES SIMULATED

The simulation plays a BLUE tank company team supported with air defense and an attack helicopter company (-) defending against an attacking RED tank company (+) which is supported with air defense and a RED attack helicopter company (-).

BLUE Task Organization

BLUE Team

Tank Company (-)

DIVAD Platoon (-)

Roland Platoon (-)

ATK Helicopter Company (-)

BLUE Weapon Systems Simulated:

10 XM1

3 DIVAD Gun

3 ROLAND missile systems

3 STINGER MANPADS

9 AAH (3 AAH, 2 ASH, per Platoon, 3 Platoons per

6 ASH company)

Initial Ammunition Load, BLUE Weapon Systems:

XM1	Does not fire
DIVAD Gun:	2000 rounds 40 mm
ROLAND System:	12 ROLAND AD missiles
STINGER:	1 AD missile
ASH:	250 rounds of 7.62 mm MG (stored as 25 bursts of 10 rounds each)
AAH:	8 HELLFIRE ATGM 250 rounds of 20 mm (stored as 25 bursts of 10 rounds each)

RED Task Organization

RED Team

Tank Company (+)

BMP Section

ZSU Platoon (-)

SA-9 Platoon (-)

Attack Helicopter Company (-)

RED Weapon Systems Simulated:

15 T72

3 BMP

3 ZSU-23/4

3 SA-9

3 SA-7 (carried on the BMP & represented as AMMO type 2 for the BMP)

7 HIND-D (3 Platoons per company with 2 Platoons con-
8 HIP-E sisting of 2 HINDs and 3 HIP's and 1 Platoon consisting of 3 HIND's and 2 HIP's)

Initial Ammunition Load, RED Weapon Systems:

T-72:	Not allowed to fire
BMP:	1 SA-7 AD missile
ZSU-23/4:	2000 rounds 23 mm
SA-9	12 AD missiles
HIND-D:	4 ATGM
	128 57 mm Rockets (stored as 4 pods of 32 rockets each)

250 rounds of 20 mm (stored as 25 bursts of 10 rounds each)

HIP-E: 2 ATGM

128 57 mm Rockets (stored as 4 pods of 32 rockets each)

250 rounds of 20 mm (stored as 25 bursts of 10 rounds each)

C. TACTICS PLAYED AND VALUES OF KEY PARAMETERS

AIR Elements

The BLUE helicopters will use MODE = 0 indirect rapid fire tactics (discussed in Chapter II, Section D), with the ASH member of the attack team selecting up to 3 (NUM.RIPPLE input) targets per engagement. The AAH member of the attack team upon directions from the ASH fires up to 3 HELLFIRE missiles (corresponds to the number of targets selected by the ASH) with a delay of 7 seconds (REACT.TIME input) between each missile fired. The RED helicopters will use MODE = 2 autonomous direct fire tactics. The probability that any given laser guided missile successfully locks onto the laser beam is .95 (LASER.LOCK.PCT input) for this simulation. The validity of the guidance is checked initially upon fire and thereafter every 10 seconds (MFCT input). The last guidance validity check will be made at .25 seconds (GUIDE.OFF input) before impact. All helicopters will employ popup tactics staying exposed for up to 30 seconds

(EXPOSED.LIMIT input) at a time and when masked will stay masked for 15 seconds (HIDE.TIME input) before poping up again. Platoon Fire Control (attribute SEL.PLT = 1) and target detection sharing among platoon members (attribute DET.PLT = 1) is played for both RED and BLUE helicopters. The mission abort and hide when fired upon tactic is played by the RED helicopters only. All helicopters will refire at missed target up to two times and will initiate a new target selection upon successful completion of an engagement.

AIR DEFENSE Elements

All air defense elements will share target information within their platoons (DET.PLT = 1) and will employ no fire control (SEL.PLT = 0), i.e., weapons free. They will refire on missed targets up to two times and will initiate a new target selection upon successful completion of an engagement. The method or rate of fire for each air defense system is indicated in Table II. The ZSU and DIVAD gun systems each carry 2000 rounds with 1000 of those rounds in a ready configuration. The reload time (to bring rounds to the ready position) being played is 120 seconds. The SA-9 and ROLAND missile systems each carry 12 missiles with 4 in a ready configuration. The reload time (to bring on board non-ready missiles to a ready position) being played is 120 seconds.

The opening or maximum ranges being played for each ammunition type of each weapon system is as follows:

TABLE II

ADA METHODS AND RATES OF FIRE

WEAPON TYPE	OUTSIDE OF RIPPLE RANGE		INSIDE OF RIPPLE RANGE	
	NUMBER OF BURSTS	ROUNDS PER BURST	NUMBER OF BURSTS	ROUNDS PER BURST
ZSU-23	2	30	4	30
DIVAD	2	.30	4	30
All Missile Systems	1	1	1	1

All missile systems use the shoot-look-shoot method of fire regardless of range. Ripple range for the ZSU and DIVAD is 500 meters.

AAH		
ATGM	-	4000 m
20 mm Cannon	-	3000 m
ASH		
7.62 mm MG	-	2000 m
HIND-D & HIP-E		
ATGM	-	4000 m
57 mm RKT	-	3000 m
20 mm Cannon	-	3000 m
ZSU		
23 mm gun	-	4000 m
DIVAD		
30 mm gun	-	4000 m
SA-9 missile	-	4500 m
RLND missile	-	4500 m
SA-7 missile	-	3500 m
STINGER missile	-	3500 m

No inferences should be made from any of the input variables just described as the values were chosen solely to exercise the model with little regard to actual weapon system characteristics.

D. ORGANIZATION OF AIR FORCES

Aircraft are organized by sorties with each sortie consisting of one helicopter platoon. All air movement between bases and attack areas is done as a sortie and movement

within an attack area is done on an individual basis. Each BLUE helicopter platoon consists of 2 sections with 2 AAHs and 1 ASH in one section and 1 AAH and 1 ASH in the other section for a total of 3 AAHs and 2 ASHs per platoon. The RED helicopter platoons also contain 2 sections with a mix of HIND and HIP helicopters.

Both BLUE and RED helicopters are deployed using the 1/3 rule, with 1/3 (1 platoon) of the helicopter force in the attack area, 1/3 en route to the attack area and 1/3 returning to or at the Forward Area Rearm and Refuel Point (FARRP). A time table illustrating how the BLUE (sorties 1 through 3) and the RED (sorties 4 through 6) sorties are dispatched to achieve this 1/3 rule is shown in Table III.

The RED FARRP or base is area 15 and the BLUE FARRP or base is area 12. The RED helicopter force can best support the RED attack from attack area 17, so the platoons are rotated through this area. The BLUE helicopter force can best support the BLUE ground defensive positions from attack areas 1 and 6. Row 1 of Table III indicates that sortie number 1 was preplaced in attack area 1 and will remain there until 380 seconds into the simulation. Row 2 of Table III indicates that sortie number 2 will be launched from area 12 (base) at time = 0.0, will arrive in Attack Area 1 at time = 390 seconds (10 seconds after sortie 1 has departed) and will depart area 1 at time = 890 seconds. Rows 3 through 6 contain the same information for sorties 3 through 6. Row 7 again refers to sortie number 1, as it

TABLE III

AIR SORTIE DEPLOYMENT TIMES

AIR SORTIE	AREA LAUNCHED FROM	LAUNCH TIME	ATTACK AREA ARRIVED AT	ARRIVAL TIME	DEPARTURE TIME
1	-	*	1	0	380
2	12	0	1	390	890
3	12	550	1	900	1300
4	15	0	17	37	530
5	15	500	17	538	1030
6	15	1000	17	1038	1530
1	12	980	1	1350	1850

* Sortie 1 was pre-positioned in Attack Area 1

Area 12 is the BLUE Base and Area 15 is the RED Base

has returned to the FARRP (area 12) to refuel and rearm and will depart for area 1 again, at time = 980. Note that sortie 1 will arrive back in an attack area at time = 1850 shortly after sortie 3 has departed from its attack area at time = 1800, thus continuing to keep 1/3 of the helicopter force in support of the ground forces at all times. If the table were extended it would show the other sorties also being launched again after rearming and refueling to arrive back at an attack area at about the time that an on station sortie is departing its attack area.

The 1/3 deployment rule just illustrated or any other deployment rule is implemented by the proper selection of values for the Air Sortie attributes pertaining to available time, launch time, estimated flight time, total flight time and turn around time. For a discussion of these attributes see Chapter III, Section F.

E. POSITIONING OF FORCES AND SCHEME OF MANEUVER

The BLUE ground forces' positions and helicopter attack areas as well as the initial RED ground positions and helicopter attack areas are shown in Figure 3. The RED forces attack from east to west on line (running from north to south) at a rate of 5 meters per second or approximately 10 miles per hour. The T-72 tanks and BMPs are in front spaced 40 meters apart with the ZSUs and SA-9's 100 meters behind the tanks and spaced 200 meters apart.

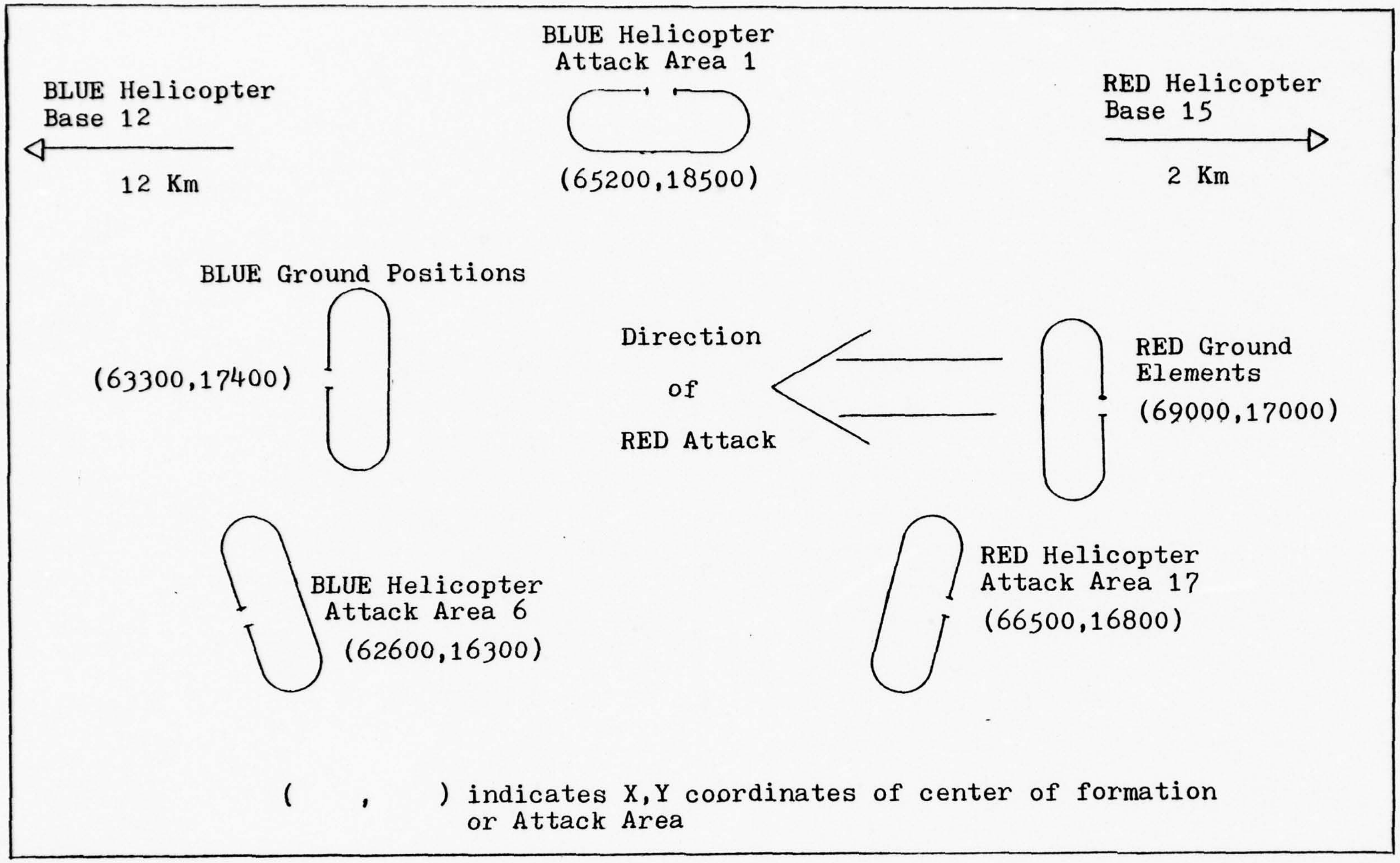


Figure 3 Initial Forces' Positions and Helicopter Attack Areas

V. SAMPLE SIMULATION

This chapter describes the simulated battle results by tracing the progress of the battle over time. Description of the sample battle is divided into 6 time segments to facilitate the presentation and to draw attention to those engagements illustrating specific features of the model. The description of each time segment of the simulation includes a table of the printed output which catalogs each round fired during that segment followed by a narrative description of the battle and a summary of the forces remaining.

The output presented in Tables IV through IX is of two forms, engagement information which is explained in Figure 4, and aircraft movement information which will be explained as it occurs in the output.

The engagements during time segment 1 are shown in Table IV. The first two lines indicate that BLUE sortie (FLT) number 2 is launched at time = 0 to Attack Area 1 and RED sortie (FLT) number 4 is launched to area 17. Sortie 1 has been prepositioned and therefore is in attack area 1 at the start of the battle. The next line in Table IV indicates that at time 37.51 flight 4 has arrived and is deploying in Attack Area 17.

Apparently during the first 56 seconds of the simulation element number 5, an XM 1 Tank, is the only BLUE element

```
RND: indicates round fired (cumulative total)
 FIR: sequential number of firing weapon syetem
   NAME: indicates type of weapon system that fired
       AM: indicates type of ammunition fired
          TGT: sequential number of target
            NAME: indicates the target weapon system type
               TIME.V: time of impact
                    STAT: result of round fired
                          blank - indicates miss
                          DEAD  - indicates target destroyed
                          HIDE  - indicates target in full defilade when round impacted
                              RANGE: slant range between target and firer
                                   X-FIR Y-FIR: X,Y coordinate of firer
                                            X-TGT Y-TGT: X,Y coordinate of target
                                                      ILL: indicates sequence num-
                                                           ber of remote illuminator

 RND  FIR NAME AM  TGT NAME  TIME.V STAT RANGE X-FIR Y-FIR X-TGT Y-TGT
  60   53 ZSU   3   23 ASH    138.2 HIDE  3799 68412 17500 64700 18300
  61   22 AAH   1   54 ZSU    160.4         3379 65200 18650 68296 17300 ILL:  23
*160.41 PCT.VIS:1.000 L%: .96 DEFB:5  A.DEAD:0 DEFA:1  C.DEAD:0 DEFC:5   VLD.CK
```

* This line, associated with the round of the previous line, is printed if guidance is lost for guided munitions. The information on this line indicates why guidance was lost.

The first number, 160.41, is the time of this validity check

PCT.VIS	-	if less than .2 intervisibility has been lost
L%	-	for this simulation if greater than .95 initial laser lock failed
DEFB	-	defilade condition of target; if equal to 1 target went into full defilade
A.DEAD	-	if equal to 1 indicates firer has been killed
DEFA	-	defilade condition of firer; if equal to 1 indicates firer is in full defilade and will cause a validity check failure only if the firer is guiding the round
CDEAD	-	if equal to 1 indicates the remote illuminator has been killed
DEFC	-	defilade condition of remote illuminator; if equal to 1 remote illuminator is in full defilade

Figure 4 Sample Output Explanation

TABLE IV TIME SEGMENT 1: SIMULATION TIME 0 THRU 97.5 SECONDS

RND	FIR	NAME	AM	TGT	NAME	TIME.V	STAT	RANGE	X-FIR	Y-FIR	X-TGT	Y-TGT	
0.		LAUNCHING FLIGHT				2	TO AREA		1				SORTIE 2
0.		LAUNCHING FLIGHT				4	TO AREA		17				SORTIE 2
37.516	T.SPD:	36.969			DEPLOYMENT OF FLT			4	OF HIND'S	WITH LCR		59	DEPLOY 2
1	60	HIND	1	5	X105	44.8		3264	66546	17341	63300	17000	
2	61	HIP	1	5	X105	45.4		3412	66700	17281	63300	17000	
3	62	HIP	1	5	X105	47.1		3395	66689	17195	63300	17000	
4	59	HIND	1	5	X105	47.8		3151	66442	17228	63300	17000	
5	63	HIP	1	5	X105	48.5		3422	66719	17126	63300	17000	
6	60	HIND	1	5	X105	53.9		3104	66400	17000	63300	17000	
7	61	HIP	1	5	X105	54.9		3405	66700	16808	63300	17000	
8	62	HIP	1	5	X105	56.6	DEAD	3391	66680	16724	63300	17000	
9	59	HIND	1	5	X105	56.6		3107	66400	17150	63300	17000	
10	60	HIND	1	17	RLND	68.5		3408	66400	17000	63000	16800	
11	15	DIVD	3	60	HIND	69.1		3427	63100	17900	66400	17000	
12	16	DIVD	3	60	HIND	69.5		3402	63100	17800	66400	17000	
13	15	DIVD	3	60	HIND	70.1	DEAD	3427	63100	17900	66400	17000	
14	14	DIVD	3	60	HIND	70.1		3454	63100	18000	66400	17000	
15	16	DIVD	3	60	HIND	70.5		3402	63100	17800	66400	17000	
16	59	HIND	1	18	RLND	70.9		3431	66400	17150	63000	16700	
17	14	DIVD	3	60	HIND	71.1		3454	63100	18000	66400	17000	
18	18	RLND	1	61	HIP	74.0		3703	63000	16700	66700	16800	
19	11	STIN	1	59	HIND	74.1		3439	63100	18100	66400	17150	
20	19	RLND	1	61	HIP	74.9		3707	63000	16600	66700	16800	
21	15	DIVD	3	59	HIND	75.2		3390	63100	17900	66400	17150	
22	16	DIVD	3	59	HIND	75.7		3369	63100	17800	66400	17150	
23	15	DIVD	3	59	HIND	76.2	DEAD	3390	63100	17900	66400	17150	
24	17	RLND	1	61	HIP	76.5		3702	63000	16800	66700	16800	
25	12	STIN	1	59	HIND	76.6		3484	63000	16400	66400	17150	
26	16	DIVD	3	59	HIND	76.7		3369	63100	17800	66400	17150	
27	63	HIP	1	6	X105	77.5		3523	66750	16200	63300	16900	
28	60	HIND	1	17	RLND	77.8		3408	66400	17000	63000	16800	ILL: 0
77.79	PCT.VIS:1.000			L%:0.		DEFB:5	A.DEAD:1		DEFA:5	C.DEAD:0		DEFC:5	VLD.CK
29	18	RLND	1	61	HIP	79.6	HIDE	3703	63000	16700	66700	16800	
30	59	HIND	1	18	RLND	80.3		3431	66400	17150	63000	16700	ILL: 0
80.27	PCT.VIS:1.000			L%:0.		DEFB:5	A.DEAD:1		DEFA:5	C.DEAD:0		DEFC:5	VLD.CK
31	19	RLND	1	61	HIP	80.5	HIDE	3707	63000	16600	66700	16800	
32	53	ZSU	3	20	ASH	92.4		3300	68637	17500	65700	19000	
33	54	ZSU	3	20	ASH	93.1		3392	68633	17300	65700	19000	
34	53	ZSU	3	20	ASH	93.4		3295	68632	17500	65700	19000	
35	54	ZSU	3	20	ASH	94.1		3388	68628	17300	65700	19000	
36	55	ZSU	3	20	ASH	94.5	DEAD	3491	68626	17100	65700	19000	
37	55	ZSU	3	20	ASH	95.5		3487	68621	17100	65700	19000	
38	53	ZSU	3	20	ASH	96.5		3282	68617	17500	65700	19000	
39	53	ZSU	3	20	ASH	97.5		3277	68612	17500	65700	19000	

detected by the RED aircraft, so consequently all RED aircraft engage element number 5. Similarly HIND helicopter number 60 apparently is the only detected target for the DIVAD platoon as all three DIVAD's (numbers 14, 15 and 16) engage element number 60 between 69.1 and 70.1 seconds of the simulation. Note that the DIVAD's are firing according to the method of engagement that was input, which is to fire two bursts with a 1 second delay between bursts. Shots 28 and 30 were both misses because the firers, HIND 59 and 60, were killed before the command guided ATGM's which they fired had impacted. Also of interest are shots 29 and 31 in which the target, HIP number 61, masked after the ROLAND missiles were launched but before they impacted.

The last series of engagements (shots 32-39) in this segment find the RED ZSU platoon engaging ASH number 20 in the same manner as the DIVAD engagements described above. Note that ZSU number 53 having missed on his first two bursts (rounds 32 and 34) immediately refires on the same target as indicated by rounds 38 and 39, however the target (ASH number 20) is killed by the burst fired by ZSU number 55 (round 36) before the rounds of ZSU 53 impact.

A summary of the forces remaining at the end of time segment 1 follows:

Summary of BLUE elements remaining at 97.5 seconds

Wpn Type	Number at Start	Number remaining
XM 1	10	9
STINGER	3	3
DIVAD	3	3
ROLAND	3	3
AAH	9	9
ASH	6	5

94.1% of the BLUE force remaining

Summary of RED elements at 97.5 seconds

Wpn Type	Number at Start	Number remaining
T-72	15	15
BMP	3	3
ZSU	3	3
SA-9	3	3
HIND	7	5
HIP	8	8

94.9% of RED force remaining

The second time segment of the battle, shown in Table V, is dominated by the air defense of both sides firing at the opposing helicopters. The remaining HIP helicopters of RED sortie 4 have expended their long range ATGMs and are beyond the range of their remaining weapon systems, so they

TABLE V TIME SEGMENT 2: SIMULATION TIME 116.0 THRU 225.5 SECONDS

RND	FIR	NAME	AM	TGT	NAME	TIME.V	STAT	RANGE	X-FIR	Y-FIR	X-TGT	Y-TGT		
40	18	RLND	1	63	HIP	116.0		3784	63000	16700	66750	16200		
41	17	RLND	1	63	HIP	117.2		3799	63000	16800	66750	16200		
42	14	DIVD	3	62	HIP	119.5		3882	63100	18000	66675	16500		
43	14	DIVD	3	62	HIP	120.5		3882	63100	18000	66675	16500		
44	16	DIVD	3	62	HIP	121.0		3810	63100	17800	66675	16500		
45	18	RLND	1	63	HIP	121.7	HIDE	3784	63000	16700	66750	16200		
46	15	DIVD	3	62	HIP	121.9		3845	63100	17900	66675	16500		
47	16	DIVD	3	62	HIP	122.0	DEAD	3810	63100	17800	66675	16500		
48	15	DIVD	3	62	HIP	122.9	DEAD	3845	63100	17900	66675	16500		
49	18	RLND	1	63	HIP	123.6	HIDE	3784	63000	16700	66750	16200		
50	55	ZSU	3	23	ASH	132.6		3925	68436	17100	64700	18300		
51	53	ZSU	3	23	ASH	132.8		3821	68435	17500	64700	18300		
52	54	ZSU	3	23	ASH	133.4		3864	68431	17300	64700	18300		
53	55	ZSU	3	23	ASH	133.6		3920	68431	17100	64700	18300		
54	53	ZSU	3	23	ASH	133.8		3816	68430	17500	64700	18300		
55	54	ZSU	3	23	ASH	134.4		3859	68426	17300	64700	18300		
56	55	ZSU	3	23	ASH	137.0		3904	68413	17100	64700	18300		
57	53	ZSU	3	23	ASH	137.2		3800	68413	17500	64700	18300		
58	24	AAH	1	53	ZSU	137.3	DEAD	3605	64900	18300	68412	17500	ILL:	23
59	55	ZSU	3	23	ASH	138.0	HIDE	3904	68413	17100	64700	18300		
60	53	ZSU	3	23	ASH	138.2	HIDE	3799	68412	17500	64700	18300		
61	22	AAH	1	54	ZSU	160.4		3379	65200	18650	68296	17300	ILL:	23
160.41	PCT.VIS:1.000			L8:	.96	DEFB:5		A.DEAD:0	DEFA:1		C.DEAD:0	DEFC:5		VLD.CK
62	16	DIVD	3	63	HIP	162.0		3990	63100	17800	66750	16200		
63	16	DIVD	3	63	HIP	163.0		3990	63100	17800	66750	16200		
64	16	DIVD	3	63	HIP	166.5	HIDE	3990	63100	17800	66750	16200		
65	16	DIVD	3	63	HIP	167.5	HIDE	3990	63100	17800	66750	16200		
66	22	AAH	1	55	ZSU	178.9	DEAD	3382	65200	18650	68204	17100	ILL:	23
67	22	AAH	1	56	SA-9	186.1	DEAD	3449	65200	18650	68169	16900	ILL:	23
68	15	DIVD	3	61	HIP	191.8		3770	63100	17900	66700	16800		
69	16	DIVD	3	61	HIP	192.2	HIDE	3743	63100	17800	66700	16800		
70	15	DIVD	3	61	HIP	192.8	HIDE	3770	63100	17900	66700	16800		
71	14	DIVD	3	61	HIP	193.0	HIDE	3800	63100	18000	66700	16800		
72	16	DIVD	3	61	HIP	193.2	HIDE	3743	63100	17800	66700	16800		
73	14	DIVD	3	61	HIP	194.0	HIDE	3800	63100	18000	66700	16800		
74	16	DIVD	3	61	HIP	218.0		3743	63100	17800	66700	16800		
75	21	AAH	1	54	ZSU	218.5	DEAD	2960	65400	18700	68005	17300	ILL:	23
76	16	DIVD	3	61	HIP	219.0		3743	63100	17800	66700	16800		
77	14	DIVD	3	61	HIP	219.7	DEAD	3800	63100	18000	66700	16800		
78	15	DIVD	3	61	HIP	219.8		3770	63100	17900	66700	16800		
79	14	DIVD	3	61	HIP	220.7		3800	63100	18000	66700	16800		
80	15	DIVD	3	61	HIP	220.8	DEAD	3770	63100	17900	66700	16800		
81	51	BMP	2	23	ASH	225.5		3408	67871	17060	64700	18300		

are unable to return the fire of the BLUE air defense. There is evidence of the use of the mission abort tactic that was input for the RED helicopters as HIP member 63, having detected the ROLAND missiles fired at him on shots 40 and 41 has masked by the time shot number 45 impacts. However, HIP number 62 is not so fortunate as rounds 42-44 miss but he is not able to mask before shot 47 impacts and kills him. This happened because the program requires 3 seconds for a helicopter to mask after detecting that it has been fired upon. HIP number 63 having popped up again is engaged on rounds 62 and 63 and again masks to avoid the impact of rounds 64 and 65.

The BLUE helicopters are not employing the mission abort tactic as is indicated by shots 50-57 against ASH number 23. Rather, the BLUE helicopters only mask after being exposed for approximately 30 seconds and not as a result of a firing simulus. It should also be noted that the only BLUE helicopters to be engaged are the ASHs since the AAHs remain masked in the MODE = 0 indirect fire tactic being used by the BLUE helicopters. We observe the first BLUE helicopter firing when, on shot 58, AAH number 24 fires a laser guided ATGM illuminated by ASH number 23 that results in a kill of ZSU number 53. ASH 23 apparently having been exposed for approximately 30 seconds, masks immediately after this last engagement and is in defilade before shots 59 and 60 impact.

Shot number 61 is the next engagement of interest in this time segment. The printout indicates that at time = 160.4 this round was adjudged a miss because the laser guided ATGM fired by AAH number 22 failed to lock on the laser beam of ASH number 23 (i.e., L% greater than .95).

As the following summary tables for this segment indicate, two-thirds of the RED air defense and almost 27% of the RED helicopters have been destroyed while the BLUE force has only sustained the loss of 1 XM-1 tank and 1 ASH.

Summary of BLUE elements remaining at 225.5 seconds

Wpn Type	Number at Start	Number remaining
XN-1	10	9
STINGER	3	3
DIVAD	3	3
ROLAND	9	3
AAH	6	9
ASH		5

94.1% of BLUE force remaining

Summary of RED elements remaining at 225.5 seconds

Wpn Type	Number at Start	Number remaining
T-72	15	15
BMP	3	3
ZSU	3	0
SA-9	3	2
HIND	7	5
HIP	8	6

79.5% of RED force remaining

TABLE VI TIME SEGMENT 3: SIMULATION TIME 226.5 THRU 530.0 SECONDS

RND	FIR	NAME	AM	TGT	NAME	TIME.V	STAT	RANGE	X-FIR	Y-FIR	X-TGT	Y-TGT	
82	21	AAH	1	57	SA-9	226.5	DEAD	3257	65400	18700	67966	16700	ILL: 23
83	52	BMP	2	23	ASH	227.4		3414	67862	17020	64700	18300	
84	50	BMP	2	23	ASH	228.0		3382	67859	17100	64700	18300	
85	21	AAH	1	58	SA-9	233.8	DEAD	3357	65400	18700	67931	16500	ILL: 23
86	17	RLND	1	63	HIP	243.4		3799	63000	16800	66750	16200	
87	19	RLND	1	63	HIP	243.8		3773	63000	16600	66750	16200	
88	17	RLND	1	63	HIP	249.2	HIDE	3799	63000	16800	66750	16200	
89	19	RLND	1	63	HIP	249.5	HIDE	3773	63000	16600	66750	16200	
90	24	AAH	1	35	T-72	267.6	DEAD	2942	64900	18300	67662	17300	ILL: 23
91	24	AAH	1	36	T-72	274.6	DEAD	2922	64900	18300	67626	17260	ILL: 23
92	24	AAH	1	37	T-72	281.5	DEAD	2904	64900	18300	67591	17220	ILL: 23
93	18	RLND	1	63	HIP	286.7		3784	63000	16700	66750	16200	
94	22	AAH	1	38	T-72	314.7	DEAD	2671	65200	18650	67425	17180	ILL: 23
95	22	AAH	1	39	T-72	321.7	DEAD	2665	65200	18650	67390	17140	ILL: 23
96	22	AAH	1	40	T-72	328.6	DEAD	2660	65200	18650	67355	17100	ILL: 23
97	21	AAH	1	41	T-72	361.1		2517	65400	18700	67192	16940	ILL: 23
98	21	AAH	1	42	T-72	368.2	DEAD	2521	65400	18700	67158	16900	ILL: 23
99	21	AAH	1	43	T-72	375.2	DEAD	2526	65400	18700	67123	16860	ILL: 23
380.000	T.SPD:	395.000 FLT				1 RTB	ON RT	1 CP.NEXT		58 CP.FINAL:	3		RTB 3
100	18	RLND	1	63	HIP	387.7		3784	63000	16700	66750	16200	
390.000	T.SPD:	368.046	DEPLOYMENT	OF	FLT	2	OF ASH 'S	WITH LDR	25				DEPLOY 2
101	18	RLND	1	63	HIP	393.5	HIDE	3784	63000	16700	66750	16200	
102	16	DIVD	3	63	HIP	413.8	HID	3990	63100	17800	66750	16200	
103	16	DIVD	3	63	HIP	414.8	HID	3990	63100	17800	66750	16200	
104	16	DIVD	3	63	HIP	418.3	HIDE	3990	63100	17800	66750	16200	
105	16	DIVD	3	63	HIP	419.3	HIDE	3990	63100	17800	66750	16200	
106	16	DIVD	3	63	HIP	462.4	HIDE	3990	63100	17800	66750	16200	
107	16	DIVD	3	63	HIP	463.4	HIDE	3990	63100	17800	66750	16200	
108	27	AAH	1	41	T-72	467.8		2249	65200	18650	66659	16940	ILL: 28
109	29	AAH	1	41	T-72	471.1		2212	64900	18300	66642	16940	ILL: 25
110	16	DIVD	3	63	HIP	492.5		3990	63100	17800	66750	16200	
111	16	DIVD	3	63	HIP	493.5		3990	63100	17800	66750	16200	
112	16	DIVD	3	63	HIP	496.9	HIDE	3990	63100	17800	66750	16200	
113	26	AAH	1	50	BMP	497.4		1950	65400	18700	66511	17100	ILL: 28
114	19	RLND	1	63	HIP	497.8	HIDE	3773	63000	16600	66750	16200	
115	16	DIVD	3	63	HIP	497.9	HIDE	3990	63100	17800	66750	16200	
116	17	RLND	1	63	HIP	498.6	HIDE	3799	63000	16800	66750	16200	
117	18	RLND	1	63	HIP	498.9	HIDE	3784	63000	16700	66750	16200	
500.00	LAUNCHING	FLIGHT				5	TO	AREA	17				SORTIE 2
118	29	AAH	1	41	T-72	500.8		2098	64900	18300	66494	16940	ILL: 25
119	29	AAH	1	52	BMP	507.6		2021	64900	18300	66460	17020	ILL: 25
120	26	AAH	1	51	BMP	511.4	DEAD	1944	65400	18700	66441	17060	ILL: 28
530.000	T.SPD:	545.000 FLT				4 RTB	ON RT	6 CP.NEXT		6 CP.FINAL:	1		RTB 3

Time segment 3, shown in Table VI, begins with the destruction of the last two RED air defense weapons (shots 82 and 85) and the firing of the last SA7 missiles by the BMP's (shots 83 and 84). This leaves the BLUE helicopters operating in an essentially threat free environment, so, they turn their attention to their next priority, the RED tanks.

Three shot groups, rounds 90 through 92, 94 through 96 and rounds 97 through 99, illustrate the MODE = 0 indirect fire tactic which calls for an ASH to select up to three targets and then illuminate the three missiles fired in succession by an AAH.

At time 380 seconds (an input parameter) BLUE sortie 1 leaves Area 1 to return to base and 10 seconds later BLUE sortie number 2 deploys in area 1 enabling the BLUE helicopter force to continue to support the BLUE defense against the attacking RED force. The one remaining helicopter (number 63) of RED sortie 4 manages to avoid the heavy fire of the BLUE air defense and departs area 17 to return to its base at time 530 seconds. RED sortie (FLT) 5 is launched to area 17 at time 500 seconds to replace sortie 4.

As the summary tables for segment 3 indicate the RED forces have been seriously attrited to 51% of their starting force. All of the RED air defense and more than 50% of its tanks have been destroyed.

Summary of BLUE elements remaining at 507.6 seconds

Wpn type	Number at Start	Number remaining
XN-1	10	9
STINGER	3	3
DIVAD	3	3
ROLAND	3	3
AAH	9	9
ASH	6	5

94.1% of the BLUE force remaining

Summary of RED elements remaining at 507.6 seconds

Wpn type	Number at Start	Number remaining
T-72	15	7
BMP	3	2
ZSU	3	0
SA-9	3	0
HIND	7	5
HIP	8	6

51.3% of the RED force remaining

Time segment 4 shown in Table VII begins with the arrival and deployment in area 17 of RED sortie 5 replacing sortie 4 that had departed 10 seconds earlier. Other airmove printouts in this segment include the launching of BLUE sortie 3 at time = 550 and the arrival of sortie 3

TABLE VII TIME SEGMENT 4: SIMULATION TIME 538.0 THRU 900.0 SECONDS

```
RND  FIR NAME AM  TGT NAME   TIME.V STAT RANGE X-FIR Y-FIR X-TGT Y-TGT
121   27 AAH   1   41 T-72    538.0 DEAD  2038 65200 18650 66307 16540 ILL:  25
540.000  T.SPD: 536.965  DEPLOYMENT OF FLT   5 OF HIND'S WITH LDR  64  DEPLOY 2
122   26 AAH   1   50 BMP     542.0 DEAD  1831 65400 18700 66288 17100 ILL:  28
123   26 AAH   1   52 BMP     542.8       1899 65400 18700 66284 17020 ILL:  28
 542.82 PCT.VIS:1.000 L%: .95 DEFB:5  A.DEAD:0 DEFA:1  C.DEAD:0 DEFC:5   VLD.CK
124   27 AAH   1   52 BMP     544.8 DEAD  1953 65200 18650 66274 17020 ILL:  25
550.00     LAUNCHING FLIGHT     3      TO AREA    6                    SORTIE 2
125   19 RLND  1   64 HIND    552.8       3446 63000 16600 66400 17150
126   17 RLND  1   64 HIND    552.9 HID   3420 63000 16800 66400 17150
127   19 RLND  1   64 HIND    558.1 HIDE  3446 63000 16600 66400 17150
128   17 RLND  1   64 HIND    558.2 HIDE  3420 63000 16800 66400 17150
129   19 RLND  1   65 HIND    568.6       3425 63000 16600 66400 17000
130   12 STIN  1   65 HIND    570.4 DEAD  3455 63000 16400 66400 17000
131   17 RLND  1   66 HIND    570.5 DEAD  3702 63000 16800 66700 16800
132   13 STIN  1   65 HIND    574.5       3475 63000 16300 66400 17000
                     FLIGHT   4   BACK AT BASE AND LANDING             ARRIVA33
133   64 HIND  1    6 X105    584.4       3113 66400 17150 63300 16900
134   16 DIVD  3   68 HIP     586.3 DEAD  3990 63100 17800 66750 16200
135   68 HIP   1   16 DIVD    586.4       3990 66750 16200 63100 17800
136   16 DIVD  3   68 HIP     587.3       3990 63100 17800 66750 16200
137   67 HIP   1    9 X105    587.6       3379 66675 16500 63300 16500
138   64 HIND  1    6 X105    593.2       3113 66400 17150 63300 16900
139   64 HIND  1   16 DIVD    604.8 DEAD  3369 66400 17150 63100 17800
140   67 HIP   1    9 X105    615.3 DEAD  3379 66675 16500 63300 16500
141   64 HIND  1   15 DIVD    635.3       3390 66400 17150 63100 17900
142   15 DIVD  3   64 HIND    640.3       3390 63100 17900 66400 17150
143   15 DIVD  3   64 HIND    641.3       3390 63100 17900 66400 17150
144   14 DIVD  3   64 HIND    641.4       3413 63100 18000 66400 17150
145   14 DIVD  3   64 HIND    642.4 HIDE  3413 63100 18000 66400 17150
146   11 STIN  1   64 HIND    670.9       3439 63100 18100 66400 17150
147   14 DIVD  3   64 HIND    701.1       3413 63100 18000 66400 17150
148   14 DIVD  3   64 HIND    702.1 DEAD  3413 63100 18000 66400 17150
149   15 DIVD  3   64 HIND    703.6       3390 63100 17900 66400 17150
150   15 DIVD  3   64 HIND    704.6 DEAD  3390 63100 17900 66400 17150
151   19 RLND  1   67 HIP     732.4       3678 63000 16600 66675 16500
152   18 RLND  1   67 HIP     733.9 DEAD  3682 63000 16700 66675 16500
153   17 RLND  1   67 HIP     735.3 DEAD  3689 63000 16800 66675 16500
                     FLIGHT   1   BACK AT BASE AND LANDING             ARRIVA33
890.000  T.SPD: 905.000 FLT  2 RTB ON RT   1 CP.NEXT  58 CP.FINAL:  3    RTB 3
900.000  T.SPD: 875.788  DEPLOYMENT OF FLT   3 OF ASH 'S WITH LDR  30  DEPLOY 2
```

in area 6 at time = 900, 10 seconds after sortie 2 had initiated a return to base from area 1.

This time segment is characterized by a heavy exchange between the BLUE air defense and the RED helicopters, with all 5 helicopters of sortie 5 being destroyed.

As the following summary tables indicate segment 4 ends with 88.2% of the BLUE force remaining and only 30.8% of the RED force remaining.

Summary of BLUE elements remaining at 900 seconds

Wpn Type	Number at Start	Number remaining
XM-1	10	8
STINGER	3	3
DIVAD	3	2
ROLAND	3	3
AAH	9	9
ASH	6	5

88.2% of the BLUE force remaining

Summary of RED elements remaining at 900 seconds

Wpn type	Number at Start	Number remaining
T-72	15	6
BMP	3	0
ZSU	3	0
SA-9	3	0
HIND	7	2
HIP	8	4

30.8% of the RED force remaining

TABLE VIII TIME SEGMENT 5: SIMULATION TIME 915.2 THRU 1105.0 SECONDS

```
RND   FIR NAME AM  TGT  NAME   TIME.V STAT RANGE X-FIR Y-FIR X-TGT Y-TGT
154    32 AAH   1   49  T-72    915.2        1837 62600 16300 64422 16460 ILL:  30
155    34 AAH   1   48  T-72    917.7 DEAD   2076 62400 16000 64410 16500 ILL:  33
156    32 AAH   1   47  T-72    922.1 DEAD   1813 62600 16300 64389 16540 ILL:  30
157    31 AAH   1   46  T-72    924.3        1585 62800 16600 64378 16580 ILL:  33
  924.26 PCT.VIS:1.000 L%: .98  DEFB:5  A.DEAD:0  DEFA:1  C.DEAD:0 DEFC:5   VLD.CK
158    31 AAH   1   45  T-72    936.4 DEAD   1525 62800 16600 64318 16620 ILL:  33
159    34 AAH   1   49  T-72    952.5 DEAD   1898 62400 16000 64236 16460 ILL:  30
160    34 AAH   1   46  T-72    959.5 DEAD   1898 62400 16000 64202 16580 ILL:  30
161    34 AAH   1   44  T-72    966.6 DEAD   1952 62400 16000 64166 16820 ILL:  30
 980.00       LAUNCHING FLIGHT    1      TO AREA    1                       SORTIE 2
1000.00       LAUNCHING FLIGHT    6      TC AREA   17                       SORTIE 2
1037.243  T.SPD:1036.966  DEPLOYMENT OF FLT   6 OF HIND'S WITH LDR  69      DEPLOY 2
162    72 HIP   1    6  X105   1049.5        3392 66687 17077 63300 16900
 1050.73 PCT.VIS:C.      L%:0.   DEFB:5  A.DEAD:0 DEFA:5  C.DEAD:0 DEFC:5   VLD.CK
163    73 HIP   1   18  RLND   1050.7        3789 66722 17051 63000 16700 ILL:   0
 1050.85 PCT.VIS:0.      L%:0.   DEFB:5  A.DEAD:0 DEFA:5  C.DEAD:0 DEFC:5   VLD.CK
164    71 HIP   1    7  X105   1050.9        3509 66700 17052 63250 16800 ILL:   0
165    69 HIND  1   17  RLND   1051.0        3420 66400 17150 63000 16800
166    70 HIND  1   17  RLND   1051.1 DEAD   3435 66425 17057 63000 16800
167    18 RLND  1   69  HIND   1053.4 HID    3431 63000 16700 66400 17150
168    17 RLND  1   69  HIND   1054.3        3420 63000 16800 66400 17150
169    19 RLND  1   69  HIND   1054.8 DEAD   3446 63000 16600 66400 17150
170    70 HIND  1   18  RLND   1062.6        3415 66400 17000 63000 16700
171    72 HIP   1   19  RLND   1062.8        3678 66675 16500 63000 16600
172    71 HIP   1    7  X105   1064.8 DEAD   3453 66700 16800 63250 16800
173    71 HIP   1   18  RLND   1064.8        3703 66700 16800 63000 16700
174    19 RLND  1   70  HIND   1068.4        3425 63000 16600 66400 17000
175    70 HIND  1   18  RLND   1071.9        3415 66400 17000 63000 16700 ILL:   0
1071.92 PCT.VIS:1.000 L%:0.      DEFB:5  A.DEAD:0 DEFA:1  C.DEAD:0 DEFC:5   VLD.CK
176    18 RLND  1   70  HIND   1072.6 HIDE   3415 63000 16700 66400 17000
177    19 RLND  1   70  HIND   1073.6 HIDE   3425 63000 16600 66400 17000
178    71 HIP   1   18  RLND   1075.1        3703 66700 16800 63000 16700
179    71 HIP   1   15  DIVD   1089.0        3770 66700 16800 63100 17900
180    73 HIP   1    8  X105   1097.3        3476 66750 16200 63300 16600
181    70 HIND  1   18  RLND   1099.6        3415 66400 17000 63000 16700
182    18 RLND  1   73  HIP    1105.0        3784 63000 16700 66750 16200
```

Time segment 5 shown in Table VIII begins with BLUE sortie 3, operating from attack area 6, destroying the remainder of the RED tank force. BLUE sortie 1 is launched at time 980 so as to arrive in the attack area when BLUE sortie 3 is scheduled to depart. RED sortie 6 is launched at time = 1000 and arrives for deployment in area 17 at time = 1037. The arrival of RED sortie 6 results in a renewed exchange (rounds 162-182) between the RED helicopters and the BLUE air defense. Of particular note are rounds 162 and 163 in which the ATGM's fired by HIPs 72 and 73 are adjudged misses because line of sight between firer and target is lost (i.e., PCT.VIS = 0.0). Also of interest is round 175 in which HIND number 70 was guiding an ATGM toward ROLAND number 18. The DEFA = 1 on the VLD.CHK line associated with round 175 indicates that the round was unsuccessful because the firer (HIND,70) having masked as a result of round 174 was in defilade when the missile impacted.

As the following summary tables indicate the RED force has been almost annihilated by the end of time segment 5. 82% of the BLUE force remains intact against only 5 RED helicopters.

Summary of BLUE elements remaining at 1105

Wpn type	Number at Start	Number remaining
XM-1	10	7
STINGER	3	3
DIVAD	3	2
ROLAND	3	2
AAH	9	9
ASH	6	5

82.3% of BLUE force remaining

Summary of RED elements remaining at 1105

Wpn type	Number at Start	Number remaining
T-72	15	0
BMP	3	0
ZSU	3	0
SA-9	3	0
HIND	7	1
HIP	8	4

12.8% of RED force remaining

Table IX contains the results for the final time segment of the simulation. Obviously the remaining RED force failed to be an effective fighting force in terms of numbers long before this last time segment, however the stop criteria

TABLE IX TIME SEGMENT 6: SIMULATION TIME 1115.6 THRU 2000.0 SECONDS

```
 RND   FIR NAME AM   TGT NAME    TIME.V STAT RANGE X-FIR Y-FIR X-TGT Y-TGT
 183    14 DIVD  3    71 HIP     1115.6         3800 63100 18000 66700 16800
 184    14 DIVD  3    71 HIP     1116.6         3800 63100 18000 66700 16800
 185    15 DIVD  3    71 HIP     1117.7 DEAD    3770 63100 17900 66700 16800
 186    71 HIP   1    15 DIVD    1118.3         3770 66700 16800 63100 17900 ILL:    0
1118.34 PCT.VIS:1.000 L%:0.    DEFB:5   A.DEAD:1 DEFA:5  C.DEAD:0 DEFC:5    VLD.CK
 187    15 DIVD  3    71 HIP     1118.7         3770 63100 17900 66700 16800
 188    15 DIVD  3    72 HIP     1147.9         3845 63100 17900 66675 16500
 189    15 DIVD  3    72 HIP     1148.9         3845 63100 17900 66675 16500
 190    14 DIVD  3    72 HIP     1149.8         3882 63100 18000 66675 16500
 191    14 DIVD  3    72 HIP     1150.8         3882 63100 18000 66675 16500
 192    15 DIVD  3    70 HIND    1153.1 HIDE    3427 63100 17900 66400 17000
 193    15 DIVD  3    70 HIND    1154.1 HIDE    3427 63100 17900 66400 17000
 194    15 DIVD  3    70 HIND    1178.6         3427 63100 17900 66400 17000
 195    15 DIVD  3    70 HIND    1179.6 DEAD    3427 63100 17900 66400 17000
 196    14 DIVD  3    70 HIND    1179.8         3454 63100 18000 66400 17000
 197    14 DIVD  3    70 HIND    1180.8 DEAD    3454 63100 18000 66400 17000
 198    15 DIVD  3    72 HIP     1185.4 DEAD    3845 63100 17900 66675 16500
 199    14 DIVD  3    72 HIP     1186.4         3882 63100 18000 66675 16500
 200    15 DIVD  3    72 HIP     1186.4 DEAD    3845 63100 17900 66675 16500
 201    14 DIVD  3    72 HIP     1187.4         3882 63100 18000 66675 16500
                            FLIGHT    2   BACK AT BASE AND LANDING              ARRIVA33
1300.000  T.SPD:1315.000 FLT  3 RTB ON RT    2 CP.NEXT   50 CP.FINAL:  3       RTB 3
1350.000  T.SPD:1348.046  DEPLOYMENT OF FLT   1 OF AAH 'S WITH LDR  21    DEPLOY 2
1480.00       LAUNCHING FLIGHT    2      TO AREA    1                       SORTIE 2
1482.00       LAUNCHING FLIGHT    4      TO AREA   17                       SORTIE 2
1519.392  T.SPD:1518.971  DEPLOYMENT OF FLT   4 OF HIP 'S WITH LDR  63    DEPLOY 2
1530.000  T.SPD:1545.000 FLT  6 RTB ON RT    6 CP.NEXT    6 CP.FINAL:  1       RTB 3
 202    63 HIP   1    19 RLND    1534.1         3798 66718 17151 63000 16600 ILL:    0
 1534.11 PCT.VIS:0.     L%:0.    DEFB:5  A.DEAD:0 DEFA:5  C.DEAD:0 DEFC:5    VLD.CK
 203    63 HIP   1    10 X105    1576.7         3506 66750 16200 63250 16300
                            FLIGHT    6   BACK AT BASE AND LANDING              ARRIVA33
                            FLIGHT    3   BACK AT BASE AND LANDING              ARRIVA33
1850.00       LAUNCHING FLIGHT    3      TO AREA    6                       SORTIE 2
1854.176  T.SPD:1848.046  DEPLOYMENT OF FLT   2 OF ASH 'S WITH LDR  25    DEPLOY 2
1860.000  T.SPD:1875.000 FLT  1 RTB ON RT    1 CP.NEXT   58 CP.FINAL:  3       RTB 3
   SIMULATION STOPPED AT 2000.00
PERCENT BLUE SURVIVORS = .82    PERCENT RED SURVIVORS = .05
```

for this sample simulation was for time = 2000 so this last segment is included in the interest of completeness. Other criteria for stopping the simulation include a designated attrition percentage or position of advance reached by the RED forces (i.e., if the RED forces advance past the BLUE defense the simulation stops). These stop simulation criteria are of course user input.

The final summary of Forces Remaining indicates that 82% of the BLUE forces survive and only 5% (2 HIP helicopters) of the RED forces survive.

Summary of BLUE elements remaining at the end of simulation (2000 seconds)

Wpn type	Number at Start	Number remaining
XM-1	10	7
STINGER	3	3
DIVAD	3	2
ROLAND	3	2
AAH	9	9
ASH	6	5

82% of BLUE force remaining

Summary of RED elements remaining at the end of simulation (2000 seconds)

Wpn type	Number at Start	Number remaining
T-72	15	0
BMP	3	0
ZSU	3	0
SA-9	3	0
HING	7	0
HIP	8	2

5% of RED force remaining

It should again be emphasized that no inferences or conclusions should be drawn from this simulation. The purpose of this sample battle is solely to demonstrate the STAR AIR/Air Defense model. The data used for the exercise was greatly simplified and in no way represents what might be the results of the model run with real weapon characteristics data and valid maneuver schemes and positions.

VI. FUTURE MODEL ENHANCEMENTS

STAR-AIR as described in this document represents a good foundation and structure for incorporating air and air defense play into STAR and hopefully will prove to be an important step towards achieving the goal of developing a true combined arms combat model. However, the effort should not stop here as there is still much to be done. It is the purpose of this chapter to highlight those areas which require enhancement to more fully portray the role of air and air defense in the combined arms environment.

The areas of most immediate importance are the fixed wing dynamic attack flight profiles and the Joint Air Attack Team (JAAT) logic which have not been thoroughly tested as of this writing. Work in these areas by the authors is continuing. Another area of significance is the incorporation of accuracy and lethality data for all systems and the creation of necessary interface routines. Depending upon the level of resolution desired for damage assessment, creation of new or incorporation of existing missile fly-out models and gun ballastic models may be necessary.

A list of other areas in which work remains to be done follows:

1. Better representation of electronic detection devices.
2. Enhancement of the detection module to include powered optics and other sighting devices.

3. Representation of electronic counter-measures.

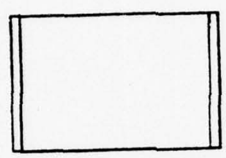
4. Better representation of long range air defense systems with multiple and diverse radar systems.

It is the intent of the authors to continue to develop the model incorporating the above items as time permits.

APPENDIX A: FLOWCHART

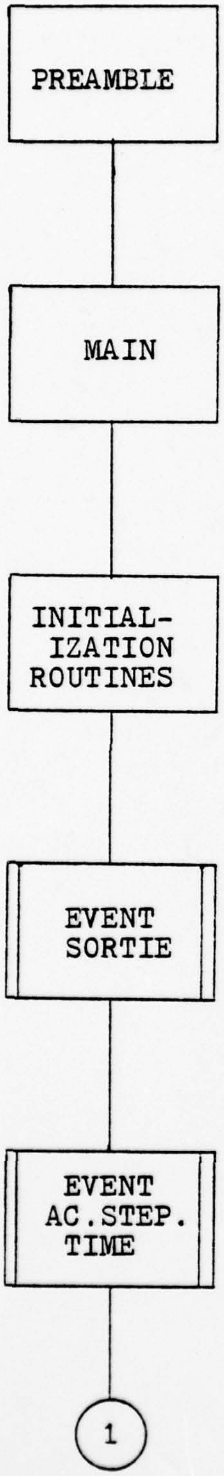
The flowchart presented in this appendix only highlights the major components of the model to show the general structure and flow of the program.

Within the flowchart the following non-standard figure is used:



an Event

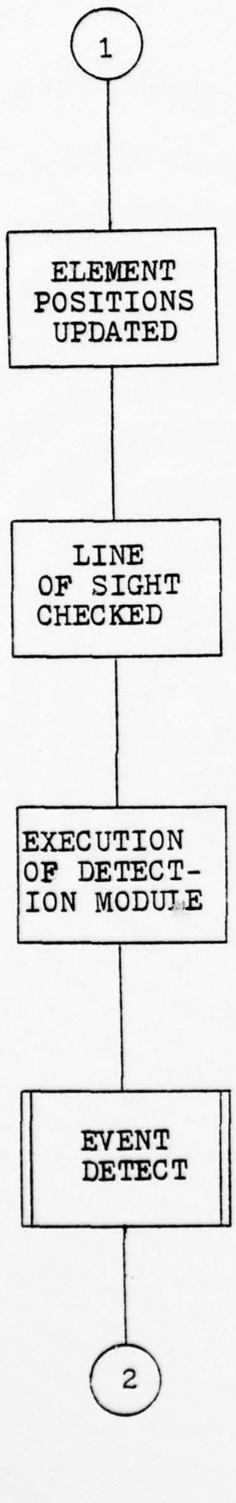
Explanatory text accompanies the flowchart.



The PREAMBLE defines all global variables, functions, sets, entities and events.

Event SORTIE launches flights according to the user input deployment scheme or to fulfill dynamically generated requests for air support.

Event AC.STEP.TIME which actually drives the simulation is recursively scheduled every AC.DELTA.T seconds. It calls appropriate routines to update positions, check line of sight and initiate the detection process as every element looks at every opposing element.



Air and ground movement routines are called to update the positions of all elements.

Line of sight is checked and element positions are updated not only at each AC.STEP.TIME but in each of the major events such as DETECT, TARGET.SELECT, FIRE, missile guidance AC.VALIDITY.CHECK and IMPACT.

Detections can be generated as a result of AC.STEP.TIME or a firing stimulus.

AD-A075 248 NAVAL POSTGRADUATE SCHOOL MONTEREY CA F/G 15/7
AN AIR TO GROUND AND GROUND TO AIR COMBINED ARMS COMBAT SIMULAT--ETC(U)
SEP 79 W J CALDWELL, W D MEIERS

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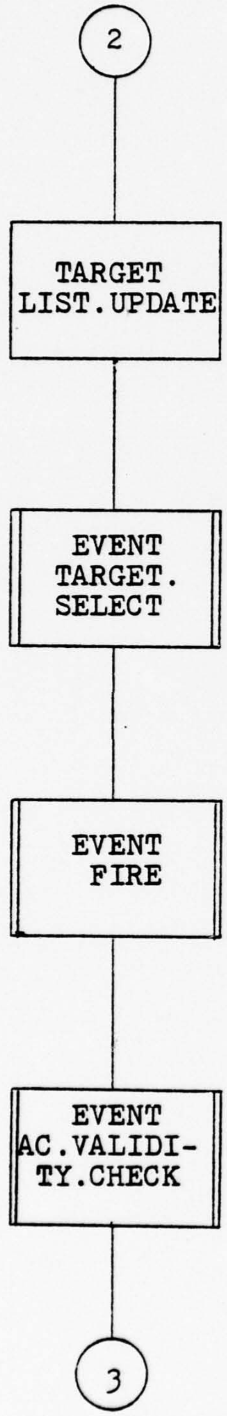
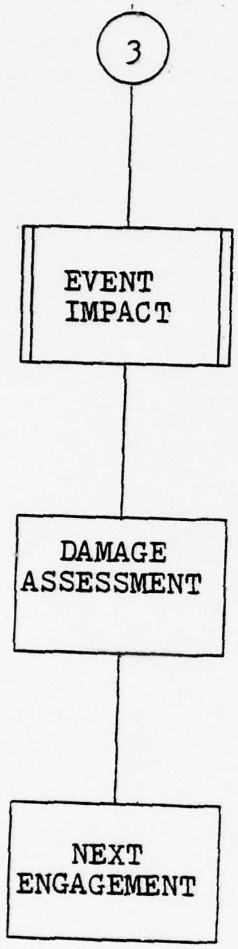


As targets are detected they are added to the detector's target list. If target information sharing is being played for the detector then the detected target is also added to the target lists of the other members of the detector's unit.

In conjunction with events TARGET.SELECT and FIRE appropriate routines are called to implement the fire control, method of engagement and tactics specified by the user.

Event AC.VALIDITY.CHECK which checks the guidance validity of commanded guided missiles is recursively scheduled throughout missile flight until impact.



The action taken upon the comletion of an engagement depends upon the results of that engagement and the tactics specified by the user.

APPENDIX B

GLOSSARY OF TERMS AND ABBREVIATIONS

AAH - Advanced Attack Helicopter

ADA - Air Defense Artillery

ALO - Air Liaison Officer

ASH - Advanced Scout Helicopter

ATGM - Anti-Tank Guided Missile

A-10 - Air Force's heavily armored, close air support jet airplane

BLUE - Team referring to friendly defensive forces

BMP - WARSAW PACT Forces' mechanized infantry carrier

Bn - Abbreviation referring to a battalion organization

CAS - Close Air Support

Co - Abbreviation referring to a company organization

DIVAD - Future U.S. Army Divisional Air Defense Gun

FARRP - Forward Area Resupply and Refuel Point; U.S. Army helicopter forward logistical supply points

Flt - Abbreviation for flight

FAC - Forward Air Controller

HELLFIRE - A laser guided anti-tank missile fired by the U.S. Advanced Attack Helicopter

Hind - WARSAW PACT Forces' assault helicopter

HIP - WARSAW PACT Forces' armed transport helicopter

Illuminator - Term used to indicate the lasing source for a laser guided missile

JAAT - Joint Air Attack Team; referring to Air Force A-10's and Army Attack Helicopters operating together as a team.

MANPADS - Man Portable Air Defense System

Plt - Abbreviation referring to a platoon organization

Remote Designator - Term referring to an element, other than the firer, that is lasing or designating a target for a laser guided missile to home in on

ROLAND - Future U.S. short range air defense missile system

SA-9 - WARSAW PACT short range air defense missile system

SA-7 - WARSAW PACT man portable air defense missile system

Sec - Abbreviation referring to a section organization

Sortie - Sortie is not used in the normal context but rather in this document a sortie is synonymous with a flight of aircraft.

STAR - Simulation of Tactical Alternative Responses; acronym for the basic ground direct fire combat model

STAR-AIR - Simulation of Tactical Alternative Responses, Air to Ground and Air Defense; an acronym for the air, air defense model developed for STAR

STINGER - Future U.S. man portable air defense missile system

T-72 - WARSAW PACT Forces' Main Battle Tank

XM-1 - Future U.S. Main Battle Tank

ZSU - WARSAW PACT Air defense anti-aircraft gun system

APPENDIX C: SAMPLE SIMULATION DATA INPUT

This appendix contains the actual data values used in the sample simulation presented in chapters 4 and 5.

TABLE X DATA VALUES INPUT BY ROUTINES MAIN AND INITIALIZE

```
   13   8   0
  1 34 35 73
 39  34  30   4   12
 INIT BFOR RFOR DRVS ECHO LOC  LOS  ARIN ELEV STME LOCK
 AGLM GALM GGLM PCET OPEN AALM LIMI OPEN OPEN CHGS DIST
 OPEN OPEN SETS SECC DETC INTA OPEN LIST TGTS CPTG PRDS
 AMMO STFI BMPT T72T IFVT XMIT ITVT BAIR TACA ATGT ASEL
 RLSE ALTC OPEN OPEN OPEN FIRE IMPC DCAM MISS WHIT COMP
 TALY MZLE HIDE WEHA WEMA PCPU LASE AFIR AIMP AHIC AVLD
 RSEL RFIR OPEN SSIM ATRT GRAV PROM DRPU OPEN OPEN OPEN
 OPEN OPEN OPEN SCRT ARMV ARST RVAL RTB  DROP ADDR DPLY
 RESP ROCK CONS LINE COMB OPEN OPEN OPEN OPEN DSTF DSTP
AAH  ASH  RLND HIND DIVD SA-9 T-72 BMP  ZSU  STIN
HIP  X1C5 OPEN OPEN OPEN OPEN OPEN OPEN OPEN OPEN
T-72 BMP  ZSU  SA-7 SA-8 SA-9 HIND HIP  OPEN OPEN
OPEN OPEN OPEN OPEN OPEN OPEN OPEN OPEN OPEN OPEN
```

TABLE XI DATA VALUES INPUT BY ROUTINES B.FORCES AND R.FORCES

```
 1    1    1       1     1     1     1       1       1       1    C
   12  0   0       37      18      100         0    1
    0  0       0    C  0   0   0     0    0   0   C   1   0    0   0   0
 2    1    1       1     1     1     1       1       1       1    0
   12  0   0       37      18      100         0    1
    0  0       0    0  0   0   0     0    0   C   0   1   0    0   0   0
 3    1    1       1     1     1     1       1       1       1    C
   12  0   0       37      18      100         0    1
    0  0       0    0  0   0   0     0    0   0   0   1   0    0   0   0
 4    1    1       1     1     1     1       1       1       1    0
   12  0   0       37      18      100         0    1
    0  0       0    0  0   0   0     0    0   C   C   1   0    0   0   C
 5    1    1       1     1     1     1       1       1       1    0
   12  0   0       37      18      100         0    1
    0  0       0    0  0   0   0     0    0   0   0   1   0    0   0   0
 6    1    1       1     1     1     1       1       1       1    0
   12  C   0       37      18      100         C    1
    0  0       0    0  0   0   0     0    0   0   0   1   0    0   0   C
 7    1    1       1     1     1     1       1       1       1    0
   12  0   0       37      18      100         0    1
    0  0       0    0  0   0   0     0    0   0   0   1   0    0   0   0
 8    1    1       1     1     1     1       1       1       1    0
   12  0   0       37      18      100         C    1
    0  0       0    0  0   0   0     0    0   0   0   1   0    0   0   0
 9    1    1       1     1     1     1       1       1       1    0
   12  0   0       37      18      100         0    1
    0  0       0    0  0   0   0     0    0   0   0   1   0    0   0   0
10    1    1       1     1     1     1       1       1       1    0
   12  0   0       37      18      100         0    1
    0  C       0    0  0   0   0     0    0   0   0   1   0    0   0   0
11    3    2       1     1     1     1       1       1      11    0
   10  1   0       2        0        0         0    2
    0  0     150    0  0   0   0     0    0   0   0   1   0    0   0   0
12    3    2       1     1     1     1       1       1      11    0
   10  1   0       2        0        0         0    2
    0  C     150    C  0   0   0     0    0   0   0   1   0    0   0   0
13    3    2       1     1     1     1       1       1      11    0
   10  1   0       2        0        0         0    2
    0  0     150    C  0   0   0     0    0   0   0   1   0    0   0   0
14    6    5       1     2     1     1       1      14      14    0
    5  1   0       0        0     2000         0    2
    0  1     150    C  0   C   0     0    0   0   0   1   0    0   0   0
15    6    5       1     2     1     1       1      14      14    0
    5  1   0       0        0     2000         0    2
```

TABLE XI (CONTINUED)

	0	1		150	0	0	0	0	0	0	0	0	1	0	0	0	0
16		6	5		1	2		1	1	1		14		14	0		
	5	1	0		C		0		2000		0	2					
	0	1		150	0	0	0	0	0	0	0	0	1	0	0	0	0
17		6	3		1	3		1	1	1		17		17	0		
	3	1	0		12		0		0		0	3					
	0	1		150	C	0	0	0	0	0	0	0	1	0	0	0	0
18		6	3		1	3		1	1	1		17		17	0		
	3	1	0		12		0		0		0	3					
	0	1		150	C	0	0	0	0	0	0	0	1	0	0	0	0
19		6	3		1	3		1	1	1		17		17	0		
	3	1	0		12		0		0		0	3					
	0	1		150	C	0	C	0	0	0	0	0	1	0	0	0	0
20		5	2		1	4		2	1	20		20		20	0		
	2	2	0		0		0		25		0	2					
	0	0		90	C	1	0	1	12	3	0	0	1	0	0	0	1
21		5	1		1	4		2	1	20		20		20	0		
	1	2	0		8		0		25		0	2					
	1	0		90	C	1	0	1	12	5	0	0	1	0	0	0	1
22		5	1		1	4		2	1	20		20		20	0		
	1	2	0		8		0		25		0	2					
	1	0		90	0	1	0	1	12	6	0	C	1	0	0	0	1
23		5	2		2	4		2	1	20		20		23	0		
	2	2	0		C		0		25		0	2					
	0	0		90	C	1	0	1	12	4	0	0	1	0	0	0	1
24		5	1		2	4		2	1	20		20		23	0		
	1	2	0		8		0		25		0	2					
	1	0		90	0	1	0	1	12	7	0	0	1	0	0	0	1
25		5	2		1	5		2	1	20		25		25	0		
	2	2	0		0		0		25		0	2					
	0	0		90	0	1	0	1	12	3	0	0	1	0	0	0	1
26		5	1		1	5		2	1	20		25		25	0		
	1	2	0		8		0		25		C	2					
	1	0		90	0	1	0	1	12	5	0	0	1	0	0	0	1
27		5	1		1	5		2	1	20		25		25	0		
	1	2	0		8		0		25		C	2					
	1	0		90	0	1	0	1	12	6	0	0	1	0	0	0	1
28		5	2		1	5		2	1	20		25		28	0		
	2	2	0		0		0		25		0	2					
	0	0		90	0	1	0	1	12	4	0	0	1	0	0	0	1
29		5	1		1	5		2	1	20		25		28	0		
	1	2	0		8		0		25		0	2					
	1	0		90	0	1	0	1	12	7	0	0	1	0	0	0	1
30		5	2		1	6		2	1	20		30		30	0		

TABLE XI (CONTINUED)

```
    2  2  0        C     0        25          0    2
    0  0     90    0  1  0   1    12     3    0  C  1   0     0  0   1
31     5  1        1     6   2     1       20     30       30    0
    1  2  0        8     0        25          0    2
    1  0     90    0  1  0   1    12     5    0  0  1   0     0  0   1
32     5  1        1     6   2     1       20     30       30    0
    1  2  0        8     0        25          0    2
    1  0     90    0  1  0   1    12     6    0  0  1   0     0  0   1
33     5  2        2     6   2     1       20     30       33    0
    2  2  0        0     0        25          0    2
    0  0     90    0  1  0   1    12     4    0  0  1   0     0  0   1
34     5  1        2     6   2     1       20     30       33    0
    1  2  0        8     0        25          0    2
    1  0     90    0  1  0   1    12     7    0  0  1   0     0  0   1
35     1  7        1     7   3     2       35     35       35    0
    7  0  0        18    22       100         0    1
    0  C      0    C  0  0   0     0     0    0  0  1   0     0  0   0
36     1  7        1     7   3     2       35     35       35    0
    7  0  0        18    22       100         0    1
    0  0      0    C  0  C   0     0     0    0  0  1   0     0  0   0
37     1  7        1     7   3     2       35     35       35    C
    7  C  0        18    22       100         0    1
    0  0      0    C  0  C   C     0     0    0  0  1   0     0  0   0
38     1  7        1     7   3     2       35     35       35    0
    7  0  0        18    22       100         0    1
    0  0      0    0  0  0   0     0     0    C  C  1   0     0  0   0
39     1  7        1     7   3     2       35     35       35    C
    7  C  0        18    22       100         0    1
    0  0      0    C  0  0   0     0     0    0  0  1   0     0  0   0
40     1  7        1     7   3     2       35     35       35    0
    7  C  0        18    22       100         0    1
    0  0      0    0  0  0   0     0     0    0  0  1   0     0  0   C
41     1  7        1     7   3     2       35     35       35    0
    7  0  0        18    22       100         0    1
    0  0      0    0  0  0   0     0     0    0  0  1   0     0  0   0
42     1  7        1     7   3     2       35     35       35    0
    7  C  0        18    22       100         C    1
    0  0      0    0  0  0   0     0     0    0  0  1   0     0  0   C
43     1  7        1     7   3     2       35     35       35    0
    7  0  0        18    22       100         0    1
    0  0      0    0  0  0   0     0     0    0  0  1   0     0  0   0
44     1  7        1     7   3     2       35     35       35    0
    7  0  0        18    22       100         C    1
    0  0      0    0  0  0   0     0     0    0  0  1   0     0  0   0
```

TABLE XI (CONTINUED)

```
45      1     7       1       7     3     2      35      35      35    0
     7    0   0      18          22      100         0    1
     0    0       0   0   0   0   0       0     0  0   0  1   0   0  0  C
46      1     7       1       7     3     2      35      35      35    0
     7    0   0      18          22      100         0    1
     0    0       0   0   0   0   0       0     0  0   0  1   0   0  0  0
47      1     7       1       7     3     2      35      35      35    0
     7    0   0      18          22      100         C    1
     0    0       0   0   0   0   0       0     0  0   0  1   0   0  0  0
48      1     7       1       7     3     2      35      35      35    0
     7    0   0      18          22      100         0    1
     0    0       0   0   0   0   0       0     0  0   0  1   0   0  0  0
49      1     7       1       7     3     2      35      35      35    0
     7    0   0      18          22      100         0    1
     0    0       0   0   0   0   0       0     0  0   0  1   0   0  0  0
50      2     8       1       7     3     2      35      50      50    0
     8    1   0       8           1      100         0    2
     0    0      90   0   0   0   0       0     0  0   0  1   0   0  0  0
51      2     8       1       7     3     2      35      50      50    0
     8    1   0       8           1      100         0    2
     0    0      90   C   0   0   0       0     0  0   0  1   0   0  0  0
52      2     8       1       7     3     2      35      50      50    0
     8    1   0       8           1      100         0    2
     0    0      90   C   0   0   0       0     0  0   0  1   0   0  0  0
53      6     9       1       8     3     2      35      53      53    0
     9    1   0       0           0     2000         0    2
     0    1     150   C   0   C   C       0     0  0   0  1   0   0  0  0
54      6     9       1       8     3     2      35      53      53    0
     9    1   0       0           0     2000         0    2
     0    1     150   C   0   0   0       0     0  C   C  1   0   0  0  0
55      6     9       1       8     3     2      35      53      53    0
     9    1   0       C           0     2000         0    2
     0    1     150   C   0   0   0       0     0  0   0  1   0   0  0  0
56      6     6       1       9     3     2      35      56      56    0
     6    1   0      12           0        0         0    3
     0    0     150   C   0   0   0       0     0  0   0  1   0   0  0  C
57      6     6       1       9     3     2      35      56      56    0
     6    1   0      12           0        0         0    3
     0    0     150   0   0   0   0       0     0  0   0  1   0   0  0  C
58      6     6       1       9     3     2      35      56      56    0
     6    1   0      12           0        0         0    3
     0    0     150   0   0   0   0       0     0  0   0  1   0   0  0  0
59      5     4       1      10     4     2      59      59      59    0
     4    2   0       4          14      100         0    2
```

TABLE XI (CONTINLED)

```
    1   0      90   0   1   0   0   15    1   C   C   1    0   0   0   1
60      5   4       1  10       4    2     59      59       59   0
    4   2   0       4      14       100       0     2
    1   0      90   0   1   0   0   15    2   0   0   1    0   0   0   1
61      5   5       2  10       4    2     59      59       61   0
   11   2   0       2       8       100       0     2
    1   0      90   0   0   0   0   15    3   0   0   1    0   0   0   1
62      5   5       2  10       4    2     59      59       61   0
   11   2   0       2       8       100       0     2
    1   0      90   0   0   0   0   15    4   0   0   1    0   0   0   1
63      5   5       2  10       4    2     59      59       61   0
   11   2   0       2       8       100       C     2
    1   0      90   0   0   0   0   15    5   0   0   1    0   0   0   1
64      5   4       1  11       4    2     59      64       64   0
    4   2   0       4      14       100       0     2
    1   0      90   0   1   0   0   15    1   0   0   1    0   0   0   1
65      5   4       1  11       4    2     59      64       64   0
    4   2   0       4      14       100       C     2
    1   0      90   0   1   0   0   15    2   0   0   1    0   0   0   1
66      5   4       1  11       4    2     59      64       64   0
    4   2   0       4      14       100       0     2
    1   0      90   0   1   0   0   15    3   0   0   1    0   0   0   1
67      5   5       2  11       4    2     59      64       67   0
   11   2   0       2       8       100       0     2
    1   0      90   0   0   0   0   15    4   0   0   1    0   0   0   1
68      5   5       2  11       4    2     59      64       67   0
   11   2   0       2       8       100       0     2
    1   0      90   C   0   0   0   15    5   0   0   1    0   0   0   1
69      5   4       1  12       4    2     59      69       69   0
    4   2   0       4      14       100       0     2
    1   0      90   C   1   C   0   15    1   0   0   1    0   0   0   1
70      5   4       1  12       4    2     59      69       69   0
    4   2   0       4      14       100       0     2
    1   0      90   C   1   0   0   15    2   0   C   1    0   0   0   1
71      5   5       2  12       4    2     59      69       71   0
   11   2   0       2       8       100       0     2
    1   0      90   C   0   0   0   15    3   0   0   1    0   0   0   1
72      5   5       2  12       4    2     59      69       71   0
   11   2   0       2       8       100       0     2
    1   0      90   0   0   0   0   15    4   C   C   1    0   0   0   1
73      5   5       2  12       4    2     59      69       71   0
   11   2   0       2       8       100       0     2
    1   0      90   C   0   0   0   15    5   0   0   1    0   0   0   1
```

TABLE XII DATA VALUES INPUT BY ROUTINE TEMP.GRD.FOS

63250	17800	0	0	0
63250	17650	0	0	0
63250	17500	0	0	0
63250	17350	0	0	0
63300	17000	0	0	0
63300	16900	0	0	0
63250	16800	0	0	0
63300	16600	0	0	0
63300	16500	0	0	0
63250	16300	0	0	0
63100	18100	0	0	0
63000	16400	0	0	0
63000	16300	0	0	0
63100	18000	0	349	0
63100	17900	0	0	0
63100	17800	0	0	0
63000	16800	0	22	0
63000	16700	0	17	0
63000	16600	0	22	0
69000	17300	5	180	180
69000	17260	5	180	180
69000	17220	5	180	180
69000	17180	5	180	180
69000	17140	5	180	180
69000	17100	5	180	180
69000	16940	5	180	180
69000	16900	5	180	180
69000	16860	5	180	180
69000	16820	5	180	180
69000	16620	5	180	180
69000	16580	5	180	180
69000	16540	5	180	180
69000	16500	5	180	180
69000	16460	5	180	180
69000	17100	5	180	180
69000	17060	5	180	180
69000	17020	5	180	180
69100	17500	5	180	180
69100	17300	5	180	180
69100	17100	5	180	180
69100	16900	5	180	180
69100	16700	5	180	180
69100	16500	5	180	180

TABLE XIII DATA VALUES INPUT BY ROUTINE AIR1.INIT

25
10

65900.00	19500.00	54.00	5.06145477
64500.00	18300.00	57.00	5.23598766
65700.00	19000.00	75.00	0.0
64700.00	18300.00	40.00	0.0
65400.00	18700.00	87.00	0.08
65200.00	18650.00	52.00	0.08
64900.00	18300.00	69.00	0.0
64600.00	19000.00	113.00	5.23598766
65000.00	19300.00	88.00	5.23598766
64700.00	18000.00	108.00	5.23598766

10

62800.00	18400.00	118.00	5.49778652
62500.00	17000.00	110.00	6.10865211
62800.00	18000.00	100.00	5.93411922
62500.00	17200.00	111.00	6.10865211
62550.00	17400.00	122.00	0.
62600.00	17500.00	129.00	0.
62650.00	17600.00	133.00	0.
62600.00	18000.00	135.00	0.
62400.00	17800.00	95.00	0.
62300.00	17500.00	79.00	0.

10

59000	19000	330	0
58000	18100	330	0
58500	18200	300	0
586500	18300	300	0
58200	18100	300	0
58400	18200	300	0
58800	18500	300	0
58000	18400	300	0
58400	18600	300	0
586007	18700	300	0

10

55000	18500	330	0
54800	18400	330	0
55000	18400	330	0
55000	17400	330	0
55000	18000	330	0
55000	17800	330	0
55000	17600	330	0
54000	18000	330	0
54000	17800	330	0

TABLE XIII (CONTINUED)

```
  54C0C   17400   330      C
10
  51700   17800   0  0
  51700   1770C   0  0
  51700   17600   0  0
  5170C   17500   0  0
  51700   17400   0  0
  51700   17300   0  0
  51700   17200   0  0
  51700   17100   0  0
  51700   17000   0  0
  51700   17900   0  0
10
          62500.00         16800.00         125.00      0.
          62300.00         15600.00          71.00      0.
          62700.00         16200.00          97.00      0.349C658
          62300.00         16000.00          49.00      0.3490658
          62800.00         16600.00          71.0C      0.3490658
          62600.00         16300.00         103.00      0.3490658
          62400.00         16C00.00          64.00      0.3490658
          62450.00         16300.00          97.00      0.
          62300.00         16500.00          73.00      0.
          62000.00         16C00.00          19.00      0.
      10
  5500C   17000   0        0
  55000   1550C   0        0
  55500   16500   0        0
  55C0C   16000   0        0
  55100   16100   0        C
  55200   16200   0        0
   5530(   16300   0       0
  54600   1650C   0        0
  54600   16400   0        0
  5460C   16000   0        0
10
  51300   14900   0  0
  51300   15000   0  0
  51300   15100   0  0
  51300   15200   0  0
  5130C   15300   0  0
  51300   15400   0  0
  51300   15500   0  0
  51300   1560C   0  0
  51300   15700   0  0
```

TABLE XIII (CONTINUED)

51300	15800	0	)	
10				
	6150C.00	15100.00	0.	.87266457
	61200.00	13800.00	34.00	.52359873
	62050.00	14400.00	18.00	.52359873
	62000.00	14C00.00	28.00	.52359873
	62100.00	14500.00	31.00	.52359873
	62C75.00	14300.00	22.00	.52359873
	62100.00	14000.00	26.00	.52359873
	61500.00	14500.00	0.	.52359873
	61450.00	14450.00	0.	.52359873
	61400.00	14400.00	0.	.52359873
10				
56100	15500	0	0	
55700	14000	0	0	
5600C	15300	0	C	
56000	14300	0	0	
56000	15100	0	0	
56C00	14700	0	0	
56000	14900	0	0	
55000	15200	0	0	
55000	15000	0	C	
55000	14700	0	0	
10				
5260C	13000	0	0	
52600	1310000	0	0	
5260C	12900	0	0	
526CC	12800	0	C	
52600	12700	0	0	
52600	12600	0	0	
5260C	12500	0	0	
52600	12400	0	0	
5260C	12300	0	0	
52600	12200	0	0	
10				
4100C	11000	0	0	
41000	11100	0	0	
41000	11100	0	0	
41C0C	11100	0	0	
41000	11100	0	0	
41000	11100	0	0	
41C00	11100	0	0	
41000	11100	0	0	
41000	11100	0	0	

TABLE XIII (CONTINLED)

	41000	11100	0	0
	10			
	40100	1300C	0	0
	40100	13000	0	0
	4C10C	13000	0	0
	40100	13000	0	C
	40100	13000	0	0
	40100	13000	0	0
	40100	13000	0	0
	40100	13000	0	0
	4C10C	13000	0	0
	401C0	13000	0	C
1				
	65200	15000	0	0
5				
	69800	19400	0	0
	69800	19400	0	0
	69800	19400	0	0
	69800	19400	0	0
	69800	19400	0	0
5				
	69100	18900	190	0
	69100	18600	190	0
	69100	18200	190	0
	69200	17900	190	0
	69200	17600	180	0
5				
	66400	17150	180	3.1417
	66400	17000	180	3.1417
	66700	16800	180	3.1417
	66675	16500	180	3.1417
	66750	16200	180	3.1417
5				
	61200	19200	210	0
	6C750	18800	210	0
	60800	18600	210	0
	60700	18500	210	0
	6C700	18200	210	0
5				
	59500	19100	240	0
	5960C	18800	240	0
	59600	18600	240	0
	59600	18300	240	0
	595CC	18100	240	0

TABLE XIII (CONTINUED)

10				
	55C0C	18500	270	0
	54800	18400	270	0
	55C00	18400	270	0
	5500C	17400	270	0
	55000	18000	270	0
	55C0C	17800	270	C
	55000	17600	270	0
	54000	18000	270	0
	54000	17800	270	0
	54000	17400	270	0
5				
	66E50	15800	1E0	180
	67000	15700	1E0	180
	67200	15400	180	180
	67300	15200	1EC	180
	67500	15000	180	180
5				
	64800	14750	120	180
	64800	14400	120	180
	64800	14000	120	180
	64800	13800	120	180
	64800	13600	120	180
5				
	62500	14400	120	180
	63200	14000	120	180
	62200	13800	120	180
	62500	14600	120	180
	62600	14800	120	180
5				
	59100	15600	1E0	0180
	59150	15100	180	180
	59200	14850	180	180
	59200	14500	180	180
	59300	13050	180	180
10				
	56100	15500	1E0	C180
	55700	14000	180	0180
	56C00	15300	180	0180
	56000	14300	180	C180
	56000	15100	180	0180
	56C0C	14700	1E0	C180
	56000	14900	1E0	0180
	55000	15200	180	0180

TABLE XIII (CONTINUED)

```
 55000  15000  180     0180
 55000  14700  1E0     C180
 1 59   1 52   1 42    1 36   1 31   2 51   2 36   2 29   3 42   3 31   3 24   10 3
10 1   4 105   10 1   6 4   6 7   6 18   6 22   6 29   7 11   7 16   7 23   7 30   7 35
 .0C001  3C   5C0   99   1   .6   .3   .1   15   45   9   5
 10   10   5   10   10   80   80   140   100   100   5   5   25   5   5   1C 10 20 10 10
  8    C    4    4    2    0    0    0    14    8    25    25    25 100 100 0 0 0 0 0
  25    0   25   25    0    0    0    0    25    25   25   25   15   25   25   0   0   0   0   0
0 0 4000 6000 21000 4000 0 11000 20000 10000 1000C 10000 0 0
 0 0 50C 1000 120C 500 C 1000 4000 200 200 200 0 0
 0 0 10 13 20 10 0 220 25 0 0 0 0 0
 0 0 120 360 120 120 0 360 360 120 120 120 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 C 0 0 0 0 0 0 0 0 0 0
 0 0 .5 .5 .5 .25 0 .5 .5 0 0 0 0 0
```

TABLE XIV DATA INPUT BY ROUTINE AIR2.INIT

```
  1   2
122.
   .5
7
   3
  6
1   0 20 0 1000 5 60  200 1 200 500 500 1 3 2 1 2 C C
  2    C 25 0 1000 5 55 190 1 200 500 500 3 3 2 1 2 0 0
3 550 30 550 10C0 5 125 200 1 2CC 5CC 500 3  3 2 1 2 0 0
4  0 59 0 600 5 35 900 0 200 500 500 7 2 3 4 5 C C
5 500 64 500 600 5 35 900 0 200 500 500 7 3 2 4 5 0 0
6 1000 69 1000 600 5 35  900 0 200 5CC 500 7 2 3 4 5 0 0
5
 1 2 1 1
6 3 1 1
17 4 1 1
17 5 1 1
17 6 1 1
0
0
  5
  81 2   88 2   54 2   85 3   84 3
  2000
289843905 1261308120 524667825 1494869952 1390129272
 339876758 2133617804 617392512 870739017 1059298902
    7
       59
     40400.000         132C0.000         265.177     50.000
     40771.391         14128.473         286.385     5C.CC0
     41000.000         14700.000         255.579     50.000
     41468.164         14875.559         281.824     50.000
     41800.000         15000.000         269.002     5C.0C0
     42641.176         14459.242         270.565     50.000
     43200.000         141C0.000         270.744     50.000
     44196.543         14016.953         265.392     5C.000
     44400.000         14CC0.000         281.158     50.000
     44617.059         13875.965         295.231     50.CC0
     45485.301         13379.824         327.388     50.000
     45915.422         13131.754         334.485     50.000
     46353.543         12883.684         310.984     5C.CCC
     46500.000         12800.000         300.000     50.000
     47454.477         12501.723         285.173     50.000
     47693.094         12427.152         315.041     50.000
     48100.000         123C0.000         305.280     50.000
```

TABLE XIV (CONTINUED)

48186.891	12792.391	323.965	50.000
48230.336	13038.586	347.862	50.000
48400.000	14000.000	361.102	50.000
48788.969	14314.168	364.250	20.000
48886.211	14392.707	385.058	20.000
48983.453	14471.246	391.192	20.000
49761.391	15099.582	325.892	20.000
49955.875	15256.664	330.731	20.000
50053.117	15335.203	339.679	20.000
50442.086	15649.371	332.531	20.000
51000.000	16100.000	282.361	20.000
51447.211	16994.426	267.272	20.000
51670.816	17441.637	306.969	20.000
51700.000	17500.000	313.317	20.000
52616.156	17099.180	271.378	20.000
53300.000	16800.000	259.278	20.000
54116.965	17376.680	280.585	20.000
54933.930	17953.359	295.512	20.000
55000.000	18000.000	311.004	20.000
55247.484	18035.352	371.073	20.000
55371.227	18053.027	389.150	20.000
56361.176	18194.445	346.986	20.000
56856.148	18265.152	338.108	20.000
57846.098	18406.570	357.858	20.000
58500.000	18500.000	405.872	20.000
58873.703	18167.816	438.741	20.000
59400.000	17700.000	387.364	20.000
60307.957	18119.055	350.908	20.000
60534.945	18223.816	401.058	20.000
60648.437	18276.195	407.965	20.000
60700.000	18300.000	405.665	20.000
61657.824	18012.652	355.490	20.000
62136.734	17868.977	376.504	20.000
62615.645	17725.301	350.237	20.000
62700.000	17700.000	340.144	20.000
62905.223	17842.766	361.869	20.000
62956.527	17878.457	403.681	20.000
62982.180	17896.301	416.822	20.000
63803.082	18467.363	351.125	20.000
64008.305	18610.129	374.036	20.000
64829.207	19181.191	374.705	20.000
65000.000	19300.000	383.718	20.000
51			
40400.000	13200.000	265.177	50.000

TABLE XIV (CONTINUED)

40771.391	14128.473	286.385	50.000
41000.000	147C0.000	255.579	50.000
41468.164	14875.559	281.824	50.000
41800.000	15CC0.000	269.002	50.000
42641.176	14459.242	270.565	5C.CC0
43200.000	14100.000	270.744	50.000
44196.543	14016.953	265.392	50.000
44400.000	14000.000	281.158	5C.CC0
44617.059	13875.965	295.231	50.000
45485.301	13379.824	327.388	50.000
45919.422	13131.754	334.485	50.0C0
46353.543	12883.684	310.984	50.000
46500.000	128C0.000	300.000	5C.CC0
47454.477	12501.723	285.173	50.000
47693.094	12427.152	315.041	50.000
48100.000	12300.000	305.280	50.CC0
48186.891	12792.391	323.965	50.000
48230.336	13038.586	347.862	50.000
48400.000	14000.000	361.102	50.000
48788.969	14314.168	364.250	20.000
48886.211	14392.707	385.058	20.CC0
48983.453	14471.246	391.192	20.000
49761.391	15099.582	325.892	20.000
49955.875	15256.664	330.731	2C.CCC
50053.117	15335.203	339.679	20.000
50442.086	15649.371	332.531	20.000
51000.000	16100.000	282.361	20.C00
51400.000	153C0.000	290.807	20.000
52268.242	15796.137	256.660	20.000
53136.484	16292.273	255.000	20.000
53500.000	165C0.000	256.058	20.000
54000.000	16500.000	287.534	20.CC0
54125.000	16500.000	319.174	20.000
54250.000	165C0.000	324.146	20.000
55000.000	16500.000	260.364	20.000
55495.273	16568.574	322.640	20.000
55619.090	16585.715	331.009	20.000
56114.363	16654.289	327.848	20.000
57104.910	16791.441	277.961	20.000
57600.184	16860.016	283.679	2C.CCC
58590.730	16997.168	332.337	20.000
59581.277	17134.320	363.812	20.000
60571.824	17271.473	420.336	2C.000
60819.461	17305.758	443.664	20.000

TABLE XIV (CONTINUED)

61314.734	17374.332	458.465	20.000
61500.000	17400.000	436.684	20.000
62000.000	17400.000	430.995	20.000
62250.000	17400.000	422.178	20.000
62300.000	17400.000	418.678	20.000
62600.000	16500.000	444.105	20.000
42			
40400.000	13200.000	265.177	50.000
40771.391	14128.473	286.385	50.000
41000.000	14700.000	255.579	50.000
41468.164	14875.559	281.824	50.000
41800.000	15000.000	269.002	50.000
42641.176	14459.242	270.565	50.000
43200.000	14100.000	270.744	50.000
44196.543	14016.953	265.392	50.000
44400.000	14000.000	281.158	50.000
44617.059	13875.965	295.231	50.000
45485.301	13379.824	327.388	50.000
45919.422	13131.754	334.485	50.000
46353.543	12883.684	310.984	50.000
46500.000	12800.000	300.000	50.000
47454.477	12501.723	285.173	50.000
47693.094	12427.152	315.041	50.000
48100.000	12300.000	305.280	50.000
48349.512	12284.402	324.177	50.000
49347.562	12222.023	286.661	50.000
49700.000	12200.000	292.317	50.000
50192.211	12287.895	310.176	20.000
51176.637	12463.684	281.332	20.000
52161.062	12639.473	272.094	20.000
52500.000	12700.000	273.539	20.000
52708.926	12837.293	291.623	20.000
52917.852	12974.586	296.501	20.000
53753.555	13523.762	255.699	20.000
54589.258	14072.937	277.253	20.000
55424.961	14622.113	282.727	20.000
55633.887	14759.406	297.744	20.000
56000.000	15000.000	284.846	20.000
56497.516	14950.246	357.196	20.000
56621.895	14937.805	367.386	20.000
57616.930	14838.301	340.121	20.000
57865.687	14813.422	381.439	20.000
58860.723	14713.918	464.184	20.000
59000.000	14700.000	471.913	20.000

TABLE XIV (CONTINUED)

59996.812	14620.254	394.059	20.000
60495.219	14580.379	448.005	20.000
60744.422	14560.441	485.047	2C.CCC
61242.828	14520.566	521.983	20.000
61500.000	145C0.000	535.382	20.000
105			
40400.000	13200.000	265.177	50.000
40771.391	14128.473	286.385	50.000
41000.000	14700.000	255.579	50.000
41468.164	14875.559	281.824	50.000
41800.000	15CC0.000	269.002	50.CC0
42641.176	14459.242	270.565	50.0C0
43200.000	141C0.000	270.744	50.000
44196.543	14016.953	265.392	5C.CC0
44400.000	14000.000	281.158	50.000
44617.059	13875.965	295.231	50.000
45485.301	13379.824	327.388	50.CC0
45919.422	13131.754	334.485	50.000
46353.543	128E3.684	310.984	50.000
46500.000	12800.000	300.000	50.000
47454.477	12501.723	285.173	50.000
47693.094	12427.152	315.041	50.CC0
48100.000	12300.000	305.280	50.000
48349.512	12284.402	324.177	50.000
49347.562	12222.023	286.661	5C.CC0
49700.000	122C0.000	292.317	50.000
50192.211	12287.895	310.176	20.000
51176.637	12463.684	281.332	20.000
52161.062	12639.473	272.094	20.000
52500.000	127C0.000	273.539	2C.CCC
52708.926	12837.293	291.623	20.000
52917.852	12974.586	296.501	20.000
53753.555	13523.762	255.699	20.000
54589.258	14072.937	277.253	20.000
55424.961	14622.113	282.727	20.000
55633.887	14759.406	297.744	20.000
56000.000	15000.000	284.846	20.000
56497.516	14950.246	357.196	20.CC0
56621.895	14937.805	367.386	20.000
57616.930	14838.301	340.121	20.000
57865.687	14813.422	381.439	20.CCC
58860.723	14713.918	464.184	20.000
59000.000	147C0.000	471.913	20.000
59996.812	14620.254	394.059	20.000

TABLE XIV (CONTINUED)

60495.219	14580.379	448.005	20.000
60744.422	14560.441	485.047	20.000
61242.828	14520.566	521.983	20.000
61500.000	14500.000	535.382	20.000
61747.863	14532.613	539.740	20.000
62739.316	14663.066	441.136	20.000
62863.246	14679.371	467.102	20.000
63854.699	14809.824	388.271	20.000
64350.426	14875.051	407.752	20.000
64598.289	14907.664	410.808	20.000
65300.000	15000.000	358.681	20.000
65432.164	15991.227	324.120	20.000
65564.312	16982.453	320.570	20.000
65630.375	17478.066	315.711	20.000
65696.437	17973.680	295.240	20.000
65700.000	18000.000	294.003	20.000
66500.000	18100.000	285.000	20.000
66358.562	17110.047	391.819	20.000
66340.875	16986.301	402.062	20.000
66199.437	15996.348	338.262	20.000
66181.750	15872.602	364.198	20.000
66040.312	14882.648	384.794	20.000
66004.937	14635.160	383.515	20.000
65987.250	14511.414	390.725	20.000
65951.875	14263.926	398.742	20.000
65810.437	13273.973	403.983	20.000
65775.062	13026.484	409.583	20.000
65633.625	12036.531	403.593	20.000
65600.000	11800.000	418.447	20.000
65476.258	11817.676	413.877	20.000
64900.000	11900.000	374.889	20.000
64963.984	12395.887	382.136	20.000
65091.953	13387.664	311.067	20.000
65219.922	14379.441	338.096	20.000
65283.906	14875.328	357.122	20.000
65300.000	15000.000	358.681	20.000
65300.000	15000.000	358.681	20.000
65236.012	14504.109	344.457	20.000
65108.039	13512.328	315.087	20.000
64980.066	12520.547	377.564	20.000
64900.000	11900.000	374.889	20.000
65394.973	11829.289	403.145	20.000
65518.715	11811.609	417.144	20.000
65600.000	11800.000	418.447	20.000

TABLE XIV (CONTINUED)

65741.375	12789.949	389.310	20.000
65776.687	13037.434	410.159	20.000
65812.000	13284.918	402.882	20.000
65953.375	14274.867	398.019	20.000
65988.687	14522.352	391.490	20.000
66059.375	15017.324	385.531	20.000
66094.687	15264.809	373.431	20.000
66165.375	15759.781	369.652	20.000
66236.062	16254.754	323.892	20.000
66271.375	16502.238	341.903	20.000
66280.187	16564.109	358.154	20.000
66315.500	16811.594	348.547	20.000
66333.125	16935.336	392.888	20.000
66350.750	17059.078	401.648	20.000
66492.125	18049.027	285.000	20.000
66500.000	18100.000	285.000	20.000
65700.000	18000.000	294.003	20.000
65633.875	17504.383	314.901	20.000
65567.750	17008.766	320.857	20.000
65435.590	16017.535	322.524	20.000
65369.508	15521.918	349.015	20.000
65303.426	15026.301	358.814	20.000
65300.000	15000.000	358.681	20.000
9			
51700.000	17500.000	313.317	20.000
51564.887	16509.168	262.612	20.000
51429.773	15518.336	268.933	20.000
51400.000	15300.000	290.807	20.000
51497.406	15069.758	313.001	20.000
51594.812	14839.516	302.403	20.000
51984.449	13918.547	274.973	20.000
52374.086	12997.578	266.395	20.000
52500.000	12700.000	273.539	20.000
29			
69800.000	19700.000	346.434	20.000
68980.750	19126.535	365.678	20.000
68878.312	19054.852	379.957	20.000
68800.000	19000.000	381.501	20.000
68374.812	18736.820	343.340	20.000
67524.500	18210.465	285.000	20.000
66700.000	17700.000	325.832	20.000
65702.937	17623.301	308.662	20.000
64705.887	17546.602	370.277	20.000
64456.621	17527.426	386.746	20.000

TABLE XIV (CONTINUED)

64207.355	17508.250	388.801	20.000
64100.000	17500.000	388.887	20.000
63962.637	17980.762	394.924	20.000
63700.000	18900.000	326.897	20.000
63201.590	18939.871	313.700	20.000
62204.773	19019.613	336.921	20.000
61207.957	19099.355	381.090	20.000
61200.000	19100.000	381.580	20.000
60226.582	19329.039	394.538	20.000
59739.871	19443.559	438.855	20.000
59618.191	19472.187	449.582	20.000
59500.000	19500.000	443.220	20.000
59250.070	19494.047	442.969	20.000
58250.352	19470.242	417.469	20.000
58000.422	19464.289	417.360	20.000
57000.703	19440.484	401.047	20.000
56500.844	19428.582	508.899	20.000
55501.125	19404.777	424.824	20.000
55300.000	19400.000	389.477	20.000
35			
69800.000	19700.000	346.434	20.000
69689.562	18706.113	376.092	20.000
69634.312	18209.168	428.403	20.000
69606.687	17960.695	439.417	20.000
69579.062	17712.223	433.431	20.000
69523.812	17215.277	407.129	20.000
69500.000	17000.000	372.875	20.000
68964.937	16155.180	344.547	20.000
68429.875	15310.359	339.372	20.000
67894.812	14465.539	335.331	20.000
67600.000	14000.000	307.326	20.000
67100.000	14000.000	376.704	20.000
66600.000	14000.000	414.160	20.000
66475.000	14000.000	426.687	20.000
65475.004	14000.000	337.875	20.000
64900.000	14000.000	340.053	20.000
64441.219	14198.801	396.391	20.000
64211.828	14298.199	412.173	20.000
64097.133	14347.898	423.482	20.000
63179.574	14745.504	422.634	20.000
62950.184	14844.902	457.325	20.000
62032.625	15242.508	471.364	20.000
61900.000	15300.000	461.826	20.000
61651.238	15275.121	466.998	20.000

TABLE XIV (CONTINUED)

61526.855	15262.680	478.846	20.000
61464.664	15256.457	482.932	20.000
60967.145	15206.703	470.993	20.000
60900.000	15200.000	468.413	20.000
60425.656	15358.113	421.700	20.000
59700.000	15600.000	371.787	20.000
59238.461	15792.305	422.116	20.000
59123.074	15840.379	427.704	20.000
58500.000	16100.000	377.168	20.000
57551.316	15783.770	310.548	20.000
56700.000	15500.000	306.247	20.000

```
5
 7   13 1  12 3  5 31  4 36  3 42  2 52  1 59
 5     13 1  12 3  8 29  7 36  6 51
   5     13 1  12 3  11 24  10 31  9 42
  3      13 1  12 3  14 105
  3    5 1   8 4   11 9
  6  15 1  16 4  17 7  18 18  19 22  20 29
  6    15 1  21 11  22 16  23 23  24 30  25 35
    5    1  2  3  4  5
  3    6  7  8
   3  9  10  11
  1  14
  3  5 8 11
  1000
   78
 8  117  174  321  398  129  362  148  315
 1    2    3    4    6    7    9   10
   1
  10
```

TABLE XV DATA INPUT BY ROUTINE AIR3.INIT

```
    7   0.25  2.  C.95  15  30  3  10
  1  1
9  13
  6  9  2  30  4  30  500  800  1   2  1000 0 120
  3  1   1  1  1  1  0  0  0  1  1 0 1CC0
  6  6  1  1  1  1  500  800  2  2  4 0 120
  6  8  1  1  1  1   0 5C00 2 2 1  0 300
  6 7 1 1 1 1 0 5000 2 2 4 0 180
  6 5 2 10 4 15 5C0 800 1 2 1000 0 120
  6 3 1 1 1 1 0 0 0 1 4 0 120
  6 10 1 1 1 1 0 C 0 2 4 0 300
  3 2 1 1 1  1 0 0 0 1 1 0 1000
```

TABLE XVI DATA INPUT BY ROUTINE CANGER.STATE

```
15  18
 1  7  14 3000 2600 2600 1200 1 1644 625 604  1 1 2 2 0 3
20    1 1 1 1   1 1 2 2   1 2 1 1   1 2 2 2   2 3 3 2   2 3 5 1   2 3 9 3
      2 4 4 2   2 4 6 1   2 4 10 3   6 5 11 1   6 5 12 2   6 5 7 3   3 6 8 3
      6 3 13 1   6 3 14 2   6 3 15 3   5 1 16 3   5 2 17 3   5 3 18 3
18    1 1 31 1   1 1 32 2   1 2 31 1   1 2 32 2   2 3 33 2   2 3 35 1
      2 3 39 3   2 4 34 2   2 4 36 1   2 4 40 3   6 5 41 1   6 5 42 2
      6 3 43 1   6 3 44 2   6 3 45 3   5 1 46 3   5 2 47 3   5 3 48 3
12    1 1 61 1   1 1 62 2   1 1 61 1   1 1 62 2   2 3 63 2   2 3 65 1
      2 4 64 2   2 4 66 1   6 5 71 1   6 5 72 2   6 3 73 1   6 3 74 2
  2 8  14 4000 2000 3500  1500 1  101  800 553 1  1 0 0 0 0
12    1 1 1 1   2 3 4 1   2 3 5 3   2 4 2 1   2 4 3 3   6 5 6 1   6 5 7 3
      3 6 8 3   6 3 9 1   6 3 10 3   5 1 11 2   5 2 11 2
12    1 1 31 1   2 3 34 1   2 3 35 3   2 4 32 1   2 4 33 3   6 5 36 1   6 5 37 3
      3 6 38 3   6 3 39 1   6 3 40 3   5 1 41 2   5 2 42 2
7     1 1 61 1   2 3 64 1   2 4 62 1   6 5 66 1   6 3 69 1   5 1 70 2   5 2 71 2
5  1  0 10000 3700 2000 2000 1 300 800 1200 1 1 1 2 15 2
11    1 7 7 1   1 7 8 3   2 8 9 1   2 8 10 3   6 9 1 1   6 9 2 3   3 1 11 3   6 7 3 1
    6 7 5 3   6 6 4 1   6 6 6 3
11    1 7 37 1   1 7 38 3   2 8 39 1   2 8 40 3   6 9 31 1   6 9 32 3   3 1 41 3
      6 7 33 1   6 7 35 3   6 6 34 1   6 6 36 3
5     1 7 64 1   2 8 65 1   6 9 61 1   6 7 62 1   6 6 63 1
5  2  0 10000  1  1  3000 1 1 1  1200  1 1 1 2 15 2
5    2 8 5 3   6 9 1 3   3 1 4 3   6 7 2 3   6 6 3 3
 5    2 8 35 3   6 9 31 3   3 1 34 3   6 7 32 3   6 6 33 3
 1 0 0 0 0
 5  3  0  5000  4000  1  200  1  400  1  1200  1 1 0 0 15 0
 13     1 7 7 1   1 7 8 3   2 8 9 1   2 8 10 3   6 9 1 1   6 9 4 3   3 1 11 3
        6 7 2 1   6 7 5 3   6 6 3 1   6 6 6 3   5 4 12 3   5 5 13 3
  13    1 7 37 1   1 7 38 3   2 8 39 1   2 8 40 3   6 9 31 1   6 9 34 3   3 1 41 3
        6 7 32 1   6 7 35 3   6 6 33 1   6 6 36 3   5 4 42 3   5 5 43 3
 13    1 7 67 1   1 7 68 3   2 8 69 1   2 8 70 3   6 9 61 1   6 9 64 3   3 1 71 3
      6 7 62 1   6 7 65 3   6 6 63 1   6 6 66 3   5 4 72 1   5 5 73 1
 5  4  0  8000 4000 3000 2000  1  400  800  1200  1 1 1 2 15 2
18    1 1 10 1   1 1 11 2   2 3 12 1   2 3 13 2   2 3 14 3   2 4 15 1
      2 4 16 2   2 4 17 3   6 5 1 1   6 5 2 2   6 5 5 3   3 6 18 3   6 3 3 1
      6 3 4 2   6 3 6 3   6 10 8 2   6 10 9 3   6 10 17 1
18    1 1 40 1   1 1 41 2   2 3 42 1   2 3 43 2   2 3 44 3   2 4 45 1
      2 4 46 2   2 4 47 3   6 5 31 1   6 5 32 2   6 5 35 3   3 6 38 3   6 3 33 1
      6 3 34 2   6 3 36 3   6 10 38 2   6 10 39 3   6 10 47 1
12    1 1 70 1   1 1 71 2   2 3 72 1   2 3 73 2   2 4 75 1   2 4 76 2
      6 5 61 1   6 5 62 2   6 3 63 1   6 3 64 2   6 10 68 2   6 10 67 1
 5  5  0  8000 4000 3000 2000  1  400  800  1200  1 1 1 2 15 2
11    1 1 7 1   2 3 8 1   2 3 9 3   2 4 10 2   2 4 11 3   6 5 1 1   6 5 4 3
```

TABLE XVI (CONTINUED)

```
        6 3 2 1    6 3 5 3    6 10 3 1    6 1C 6 3
11      1 1 37 1    2 3 38 1    2 3 39 3    2 4 40 2    2 4 41 3    6 5 31 1
        6 5  34 3    6 3 32 1    6 3 35 3    6 10 33 1    6 10 36 3
 6      1 1 67 1    2 3 68 1    2 4 70 2    6 5 61 1    6 3 62 1    6 10 63 1
  6   9 0 4000 1 4000 4000 1 1 1600 1600 1 1 1 2 0 2
 8      2 3 5 3    2 4 8 3    6 5 7 3    3 6 6 3    6 3 9 3    5 1 2 3    5 2 3 3
        5 3 1 3
 8      2 3 35 3    2 4 38 3    6 5 37 3    3 6 36 3    6 3 39    3    5 1 32 3
        5 2 33 3    5 3 31 3
 8      2 3 65 3    2 4 68 3    6 5 67 3    3 6 66 3    6 3 69 3    5 1 62 3
        5 2 63 3    5 3 61 3
  6   6   0  4000   4500   1   1   1   800   1   1   1   0 1 2 0 2
  3     5 1 2 1    5 2 3 1   5 3 1 1
 3    5 1 32 1   5  2 33 1   5 3 31 1
  3   5 1 62 1   5  2 63 1   5 3 61 1
  6   8   0  20000   12000   1   1   1   1000   1   1   1   C 1 2 0 2
  3     5 1 2 1    5 2 3 1   5 3 1 1
 3    5 1 32 1   5  2 33 1   5 3 31 1
  3   5 1 62 1   5  2 63 1   5 3 61 1
  6   7   0 11000   6000   1   1   1   900   1   1   1   0 1 2 0 2
  3     5 1 2 1    5 2 3 1   5 3 1 1
 3    5 1 32 1   5  2 33 1   5 3 31 1
  3   5 1 62 1   5  2 63 1   5 3 61 1
  3   2   0  4000   3500   1   1   1   800   1   1   1 0 1 2 C 2
  2   5 4 1 1    5  5 2 1
  2   5 4 31 1   5  5 32 1
  2     5 4 61 1   5 5 62 1
  6   5   0  4000   1  400C 4000   1   1   1600   1600   1 0 1 2 0 2
 7      2 8 5 3    6 9 4 3    3 1 8 3    6 7 6 3    6 6 7 3    5 4 1 3    5 5 2 3
 7      2 8 35 3    6 9 34 3    3 1 38 3    6 7 36 3    6 6 37 3    5 4 31 3
        5 5 32 3
 7      2 8 65 3    6 9 64 3    3 1 68 3    6 7 66 3    6 6 67 3    5 4 61 3
        5 5 62 3
  6   3   C  6000   4500   1 1 1   800 1 1 1 0 1 2 0 2
  2     5 4 1 1    5 5 2 1
  2   5 4 31 1    5 5 32 1
   2    5 4 61 1    5 5  62 1
  6   4   0  21000   60000   1   1   1   1500 1 1 1 0 1 2 0 2
 1      C C 0 0
 1      0 0 0 0
 2      5 4 61 2    5 5 62 2
```

BIBLIOGRAPHY

1. Clark, G.M., Parry, S.H., Hutcherson, D.C. and Rheinfrank III, J.J., Small Unit Combat Simulation (DYNTACSX), Air Defense Operations Models, Vol. 1, March 1971.

2. Defense Intelligence Agency, DDB-2680-40-78, Handbook on the Soviet Armed Forces, February 1978.

3. Department of the Army, FM 17-50, Attack Helicopter Operations, July 1977.

4. Department of the Army, FM 44-3, Air Defense Artillery Employment Chaparral/Vulcan, September 1973.

5. Department of the Army, FM 100-5, Operations, July 1976.

6. Department of the Army, IAG-13-U-78, Soviet Army Operations, April 1978.

7. Hartman, J.K., Parametric Terrain and Line of Sight Modelling in the STAR Combat Model, August 1979.

8. Johnson, G.D., SIMSCRIPT II.5 User's Manual S/360-370 Version, Consolidated Analysis Centers, Inc., 1974.

9. Kelleher, E.P., Simulation of the Tactical Employment of Field Artillery, M.S. Thesis, Naval Postgraduate School, Monterey, December 1977.

10. Kiviat, P.J., Villanueva, R., and Markowitz, H.M., SIMSCRIPT II.5 Programming Language, 2nd Edition, Consolidated Analysis Centers, Inc., 1973.

11. Naval Postgraduate School Technical Report, Documentation of STAR, to be published.

12. Needles, C.J., Parameterization of Terrain in Army Combat Models, M.S. Thesis, Naval Postgraduate School, Monterey, March 1976.

13. SIMSCRIPT II.5 Reference Handbook, Consolidated Analysis Centers, Inc., March 1976.

14. U.S. Air Force Tactical Air Command and U.S. Army Training and Doctrine Command, TACP 50-20/TRADOC 17-50-3, Joint Air Attack Team Operations.

15. Wallace, W.S., and Hagewood, E.G., Simulation of Tactical Alternative Responses (STAR), M.S. Thesis, Naval Postgraduate School, Monterey, December 1978.

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